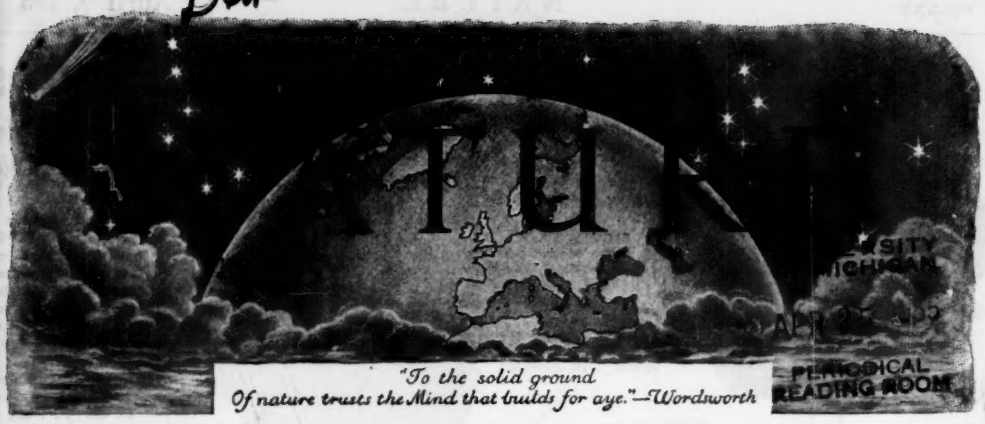

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NATURE

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DEVELOPMENT OF NUCLEAR POWER IN BRITAIN

IT was appropriate that the White Paper outlining the Government's programme in connexion with nuclear power* should be published in the same week as the Statement on Defence† which announced the Government's intention to undertake the development and production of thermonuclear weapons. Whether we are concerned with the military programme, or with the production and use of radioisotopes and other peaceful applications of nuclear energy, progress is ultimately determined by the magnitude of our scientific and technical resources, the ability of our scientists to discover the secrets of Nature and on our speed in applying the new techniques that science has taught us. These indeed, as the White Paper reminds us, are the factors which likewise determine the future of Britain as an industrial country. The Defence debate in the House of Commons showed little awareness of the limitations which might be imposed by shortage of scientific man-power, but that could not be said of the earlier debate on February 25 on a motion of Mr. Ronald Bell's welcoming the Government's programme for the development of nuclear power.

Congratulating the Government on the courage and imagination shown in putting forward this programme, and also paying tribute to the work of the Atomic Energy Authority, Mr. Bell referred to the possibility that the programme could absorb the whole output of physics graduates from British universities for several years to come. That clearly could not be allowed to happen; but, as Mr. Bell rightly said, the programme may well intensify the shortage of scientists and it gives yet greater urgency to the problem of science teachers. The recommendations of the Burnham Committee for special allowances for teachers of advanced work which the Government has accepted should have some effect; but the action which Sir David Eccles said as recently as March 3 that he was still considering in regard to the shortage of science teachers now assumes importance in respect both of defence policy and the development of nuclear power.

That could also be said of the expansion of technological education to which also Mr. Bell referred, as did even more emphatically Mr. Bernard Braine, Mr. F. Willey, Mr. George Chetwynd and Mr. M. Follick. Mr. Braine put the question in a somewhat wider context in referring to our relative expenditure on fundamental research and on applied research and the dissemination of information. Quoting the Government provision for research in the current year as £20·7 million, apart from that proportion of the recurrent grants to the universities spent on research, he urged a closer scrutiny of fundamental research and greater readiness to discontinue fruitless lines and so avoid waste of effort, and also that more Government resources should be expended on applied research. While Britain's expenditure on defence research has not been disclosed, the total expenditure of the United States last year on all kinds of research, including defence, was estimated at £750 million. In particular, he suggested that more assistance might be given to medical research in such matters as radiation sickness.

In replying for the Government in the debate, the Minister of Works, Mr. Nigel Birch, admitted that a main factor in the speed with which the programme is developed will be our ability to train the men we need, and he recognized that the universities and industry as well as the Atomic Energy Authority will play a part. Mr. Birch mentioned particularly the efforts being made at Queen Mary College, London, and at the Universities of Birmingham and Manchester. A six weeks full-time postgraduate course on nuclear engineering (the use of the term 'engineering is noteworthy) at Manchester is specially designed for industrialists, and the Government hopes that in time all universities will give basic courses in nuclear and reactor physics. As regards the training courses at Harwell, the object is to build up teams from the British Electricity Authority and teams including consulting engineers, heavy electrical engineers and other engineering firms which would be competent to execute the plans outlined in the White Paper.

Mr. Birch referred also to some of the more imaginative uses which are being made of radioactive isotopes, and said that the Atomic Energy Authority is always willing to help with any problem which the use of isotopes or nuclear technology promises to solve. Frequent reference was made in the debate to the question of safety. The statement in the White Paper that it is impossible for an 'atomic explosion' to occur in a power reactor was emphasized, and in support of the assertion that if nuclear power facilities are properly designed any accidents that occur will be no more dangerous than accidents in many other industries, Mr. Birch could point to the exceptionally good record of safety of the Authority. The main hazards in a nuclear power station are caused by the concentration of highly radioactive materials; but these are known dangers, and in guarding against them by precautions in the design of the reactor itself and, if necessary, enclosing part or all of it in a gas-tight container we are, as Mr. Birch reminded the House, not starting from scratch.

The debate appeared to be of some value in dispelling misgivings on the grounds of safety, and also in regard to the disposal of atomic waste. This is not a major problem and is primarily one for the chemical processing plants, which will be few in number, and not for the power stations. As the White Paper indicates, the volume of waste will be small, and, apart from the efforts being made to determine the most economical methods of storage or disposal, much of the output should be absorbed by the valuable uses already discovered; any material discharged will be tested to ensure that it is of extremely low

*A Programme of Nuclear Power. Pp. ii+22. (Cmd. 9389.) (London: H.M. Stationery Office, 1955.) 9*d.* net.

†Statement on Defence, 1955. Pp. 30. (Cmd. 9391.) (London: H.M. Stationery Office, 1955.) 1*s.* net.

radioactivity, so that it will be harmless and comparable in effect to the natural background radioactivity always present. Mr. Birch gave a forthright assurance on this point; but there is clearly room for publicity to dispel the unreasonable fears which have already been encountered, for example, in the Forest of Dean.

While the debate may assist in this respect, its chief interest lies in the evidence it affords of the support from all parties for the Government's programme, the extent to which the implications of that programme are understood in Parliament and the well-deserved tributes paid to British science and technology in this field. It is clear, for example, that the Government intends to make it possible for British industry to acquire the experience necessary for the full exploitation of nuclear power by providing opportunity for first-hand experience with the problems of the design and building of nuclear plant. The use of nuclear fission as a source of heat to drive electric generating plant on a commercial scale appears practicable, moreover, when the great and growing demand for energy, and especially for electric power, places an increasing strain on the supplies of coal in Britain and makes the search for supplementary sources of energy a matter of urgency. Accordingly, as Mr. Geoffrey Lloyd, Minister of Fuel and Power, indicated in his statement on February 15, this programme is of crucial importance to the national economy and has an essential place in the Government's fuel policy. The provisional programme would provide 1,500–2,000 megawatts of nuclear power by 1965 and between 10,000 and 15,000 megawatts by 1975, and by levelling off the coal required by power stations in the region of 60–70 million tons a year would help to meet the difficulties in finding manpower for the mines and producing sufficient coal at reasonable cost for other users of solid fuel.

The decision to proceed with this provisional nuclear power programme does not depend on precise comparisons of cost; but it is estimated that with the two types of reactor to be brought into use on a commercial scale during the next ten years—the gas-cooled graphite-moderated 'thermal' reactor now being constructed at Calder Hall, using natural uranium or slightly 'enriched' uranium as fuel, and a liquid-cooled 'thermal' reactor which could use the plutonium produced in the earlier reactors in conjunction with natural uranium—the cost of electricity, taking a reasonable value for the plutonium, would be about 0·6*d.* a unit. If reactors of the fast breeder type now being built at Dounreay, which should be producing electricity in 1957, are eventually used, the net cost of fuel would be greatly reduced; but the provisional programme does not contemplate using such reactors, since the necessary data and experience will not be available in time.

These estimates assume that all the plutonium is used for civil purposes, and the programme is based essentially on the assumption that the development of nuclear power has reached a stage when it is vital for us to apply it commercially with all speed if we are to keep our place as a leading industrial nation and reap the benefits nuclear power offers. It should be remembered, moreover, that in these comparative estimates of cost, no allowance is made for the rise in the price of solid fuel that would accompany the failure of supplies to keep pace with demand or for the effect of such failure on the national economy. These considerations alone would justify the effort which the provisional programme demands; and criticism of the programme in the House of Commons centred rather on the rate of progress than on the magnitude of programme. While the Government considers that enough uranium will be available for this programme over the next ten years, the programme as outlined represents the most that can reasonably be expected in the light of existing knowledge. If no unexpected difficulties or shortages of man-power or materials are encountered, progress may well be more rapid than is forecast; equally it could be slower.

The nuclear power stations will be built in the normal way by private industry for the electricity authorities, which will own and operate them. The Atomic Energy Authority will be responsible for giving technical advice on the nuclear plant; but British industry and consulting engineers have a major task in training staff, in creating the necessary organization and in designing the stations. Although this work has already begun, it will not be practicable to start building any commercial stations before 1957, when construction of two gas-cooled graphite-moderated stations (each with two reactors) will be started. These stations should come into operation during 1960–61.

Meanwhile, in 1958–59 construction of two further stations, similar in type, but with improved performance, particularly in heat rating, is planned, followed by four more in 1960 and a further four in 1961–62. These might come into operation in 1963–64 and the last four might be of the liquid-cooled type, which should then have been developed sufficiently to be economically satisfactory. Thus, if all goes well, by the end of ten years Britain should have twelve large nuclear power stations saving coal to the extent of five to six million tons a year and providing 1,500–2,000 megawatts, the latter figure being approximately equal to the new generating capacity which Britain is expected to be needing each year by the end of ten years. By 1964, the early reactors should be supplying several hundred kilograms of plutonium a year. This would be available for enriching the fuel charges in later reactors, which in turn would produce plutonium more rapidly, thus making it available for a rapidly expanding programme of reactors requiring enriched fuel in the late 1960's.

The capital expenditure involved by this programme is considerable. For the first two stations it is put between £30 million and £35 million. The next two stations, with a much higher output, will probably cost slightly more, and the last eight stations a total of about £125 million. With a further £40 million for the initial charges of uranium, including fabrication, new ancillary plant costing £30 million over the decade and concurrent capital expenditure on prototype development of £30–40

million, the cost of the ten-year programme is likely to exceed £300 million, since the rate of expenditure on commercial applications of nuclear power is likely to rise steadily during the period, and expenditure on stations which will not be completed until after 1965 does not appear in the present programme.

While this investment is not wholly an additional demand on the economy, it is obviously of a magnitude which will put a considerable strain on the capital resources of Britain, as well as on the supplies of material and man-power. The Government professes to be satisfied that the country can afford the proposed rate of investment, and the demands which the programme makes upon materials and on scientific and technical man-power; though it appears to regard the latter as the limiting factor for the present. The White Paper points out that in the absence of nuclear power, the electricity authorities would be required to invest some £1,200 million over this decade in new coal- or oil-fired generating capacity. Moreover, from about 1965, it may be economically desirable to build nuclear power stations instead of coal-fired stations, even without taking account of any long-term difficulties in the supply of coal. By 1965 the new nuclear power stations should be meeting a quarter of the total requirement of new generating capacity.

Any attempt to forecast developments after 1965 is clearly premature. Too much depends on the speed of technical development and the success of the early stations as well as on the speed with which the necessary techniques are mastered by industry as a whole. The supply of nuclear fuel may also be a limiting factor, though it is suggested that uranium is more plentiful than was once thought and that greater economy in its use may offset some of the demand, as well as developments in the use of thorium as substitute. Even so, the White Paper forecasts the possibility of nuclear power stations meeting the total requirements of new generating capacity in Britain by the early 1970's, and by 1975 producing electricity at a rate equivalent to a saving of 40 million tons of coal a year.

Before considering the scientific implications of the programme more particularly, two further points made in the White Paper should be noted. It is emphasized that the Government intends to play a full part in the international scientific conference on the peaceful uses of nuclear energy to be held in August, and that it is anxious to promote international co-operation in this field. So far as resources permit, it proposes to provide further facilities for physicists and engineers from other countries to attend the Reactor and Isotope Schools at Harwell, and to help other countries to build experimental and developmental reactors. It would seem to be sounder policy to concentrate the resources of Britain upon providing training facilities rather than to supply from among our own limited numbers of physicists and engineers the experts which other countries will require to build their nuclear energy plants.

The White Paper also refers to the possibility of building up a valuable export trade. This has already been achieved in radioactive isotopes. The experience gained by British industry in designing and building nuclear power stations during the next ten years should lay the foundations for a rapid expansion both at home and overseas. At present, nuclear power generation is still in the development phase. If, however, this pioneering programme is carried out with imagination and energy as well as with sound technical judgment, the construction and operation of such stations will become standard engineering practice and we shall then be in a position to fulfil our traditional role as an exporter of skill, to the benefit both of ourselves and the rest of the world.

It will be noted that the Atomic Energy Authority, while giving as much assistance and advice to industry as possible, will remain primarily a research and development organization, and will continue to design, build and operate pioneering types of power reactor. The Authority will also be responsible for buying uranium, fabricating the fuel elements, processing the used fuel and extracting the plutonium from it. Nevertheless, it is broadly true that the programme as outlined is a tribute to the achievements of British nuclear scientists and technologists, and simultaneously a challenge to British industry to turn these achievements swiftly to account.

The soundness of the economic assumptions in this provisional programme need not be discussed here. What is important is that the implications for science and technology should be clearly understood. In the first place, there is a continuing need for research, notably in problems of constructional materials and heat transfer, as well as in nuclear physics. Chemists and chemical engineers as well as physicists and mechanical and electrical engineers will be required for research as well as for constructional purposes. We are given no hint as to the extent of that demand or of the possible effect on the universities of a response to the appeal to provide courses in nuclear and reactor physics. In at least certain categories the shortage of scientific and technical man-power is likely to become even more acute.

Something more will obviously be required than the circular which the Federation of British Industries has now sent to its members, or the new allowances for teachers of advanced work recommended by the Burnham Committee, if the shortage of science teachers is not to curtail very seriously during the next decade the supply of physicists and other scientists needed for the programme. The programme itself could perhaps be used for demonstrating to parents, schoolmasters and pupils the opportunities and the national importance of a scientific and an industrial career. But it is equally important that some further attention should be given to the distribution and balance of our existing scientific and technical man-power.

What the programme demands above all is a conspectus of the scientific and technical man-power of Britain, a survey which the Government has hitherto refused to face. A programme of nuclear power cannot wisely be considered or pursued in isolation. Regard must be had to the demands of many other

vital sectors of the economy—to the impending programmes of road construction, of re-equipping the railways, of handling air pollution and fuel policy, as well as scientific and industrial research by government agencies, the national corporations and private industry, and also Colonial development and welfare programmes and technical assistance schemes overseas. The effect upon research and upon teaching at the universities must also be considered, and our policy of technical and technological education as well as of university education may equally require adjustment.

There is required, in fact, what may be described loosely as a national policy for science and technology. It is equally forced upon us by the demands of defence on science and technology, and neither the Advisory Council on Scientific Policy nor the Defence Research Policy Committee is by itself adequate. The major responsibility lies on the Lord President of the Council, who has still an inadequate staff, and who is without a spokesman in the House of Commons. The Parliamentary and Scientific Committee could render no greater service at this juncture than to press upon the Government the need for establishing adequate means for reviewing at a high level the implications of all the conflicting demands which such programmes place upon our scientific and technical resources; unless this is done, it is difficult to see how to avoid creating bottlenecks or distorting the balance of that effort in ways detrimental to the national welfare. Moreover, such representations would come the better from an all-party body, for the avoidance of waste and inefficiency depends increasingly on the extent to which our scientific and technical effort is applied continuously in the chosen directions and is not disturbed or deflected by party political considerations in matters where scientific and technical factors should be the first determinants. Nor should such an approach fail to promote the climate in which creative scientific and technological work and initiative best flourish, by stimulating the freer exchange of knowledge and ideas and the removal of secrecy measures which endanger rather than promote national security. It should also stimulate the imaginative consideration of the social and industrial consequences of the wider use of electric power and of the methods of automatic control which nuclear power promises to place within our reach.

SCIENCE IN EARLY CHINA

Science and Civilization in China

By Dr. Joseph Needham. With the research assistance of Wang Ling. Vol. 1: Introductory Orientations. Pp. xxxviii+318+13 plates. (Cambridge: At the University Press, 1954.) 52*s*. 6*d*. net.

IN this volume we have the beginnings of one of the most interesting books on China that has appeared for a long time. In later volumes (some of which are finished or even in the press), Dr. Joseph Needham will deal with astronomy and geography (Vol. 3), textile technology (Vol. 4), alchemy and chemistry (Vol. 5), and biology, agriculture and medicine (Vol. 6). There is, therefore, much to wait for. Dr. Needham is well equipped for the task he has set himself. Not only is he an eminent scientist, but also he is a scholar well fitted with the tools of sinology.

In the first volume of the series he discusses such matters as a geographical and historical introduction, and conditions of progress of scientific ideas and techniques between China and Europe, so that by reading the present volume we may be well prepared for the six volumes that are yet to come.

No book has appeared which attempted to bring into line such things as an account of the travels of the Emperor Mu, the influence of Chinese mathematics on Hindu mathematics, or the "Pên Tshao" series of works (herbals to be used in pharmacy or for the prevention of famine). The question of the westward flow of techniques is also dealt with—the rotary fan and the winnowing machine. The two efficient harnesses for draft animals, canal lock gates, printing and porcelain, and many other subjects are discussed and will be treated in greater detail in later volumes.

Of the introduction of natural products into China, Dr. Needham speaks of the grape-vine and alfalfa, which are clearly attributed to Chang Ch'ien (140 B.C.) in the "Shih Chi", as well as the chive, coriander, cucumber, fig, pomegranate and walnut introduced at various times between the third and seventh century A.D. Of these, no fewer than five have names which include the word *Hu*, meaning Central Asia or Persia.

One of the interesting things of which Dr. Needham writes is the striking water-clock; but there is one T'ang reference which he does not quote. In the "Ch'ao yeh Ch'ien tsai" (par. 25 *B*), by Chang Tsu, who was born in A.D. 660, is a description of a clock the English translation of which reads: "In A.D. 692, during the reign of the Emperor Wu, craftsmen from Hai-Chou made a revolving time piece. When it turned due south, it was midday, and a door opened and horse-headed men appeared. It revolved without the slightest inaccuracy" (E. D. Edwards, "Chinese Prose Literature of the T'ang Period", Vol. 1, p. 77). However, perhaps this will be referred to in a later volume.

On "What not to forget to take with you on a Journey" ("Wang Huai Lu"), Dr. Needham mentions a raincoat, a medicine chest, spare clothes, a bag of preserved goods and tea, another containing paper, ink, scissors, a rhyming dictionary and a lute. Candles, knives, chessmen and a folding chess-board must also not be forgotten. As this was written in the Sung Dynasty, about A.D. 1070, it may be seen that the Chinese did not travel too lightly. The list might be suitable if one were travelling in China now.

One of the most important of Dr. Needham's statements is the following: "Whenever one follows up any piece of scientific or zoological history in Chinese Literature, it is always at the Sung Dynasty that one finds its major focal point. This is true for applied as for the pure sciences". If one looks at chemistry or medicine, one finds that this is so, and as is well known, the use of explosives was discovered and they were utilized in the Chin–Sung wars. In the Sung period, books on pharmaceutical botany "reached an unprecedentedly high standard and several recensions of the *Pên Tshao* or Codex were produced". There were also monographs on bamboos, aromatic plants and flowering trees as well as Crustacea, birds and fishes. About A.D. 1111 an

Imperial Medical Encyclopædia, the "Shêng chi tsung lu", was compiled by twelve of the most eminent medical men of the time.

Dr. Needham has included bibliographies of Chinese books before A.D. 1800, Chinese and a few Japanese books and general articles since A.D. 1800, and books and general articles in Western languages. Apart from the paucity of Japanese books, the bibliographies are excellent. The work is beautifully produced by the Cambridge University Press, and we eagerly and impatiently await the later volumes.

E. D. EDWARDS

TEXT-BOOKS OF GEOLOGY

Petrography

An Introduction to the Study of Rocks in Thin Sections. By Howel Williams, Francis J. Turner and Charles M. Gilbert. (A Series of Geology Texts.) Pp. x+406. (San Francisco: W. H. Freeman and Company; London: Bailey Bros. and Swinfen, Ltd., 1954.) 6.50 dollars; 56*s*.

Rocks and Mineral Deposits

By Prof. Paul Niggli. English translation by Prof. Robert L. Parker. (A Series of Geology Texts.) Pp. xiii+560. (San Francisco: W. H. Freeman and Co.; London: Bailey Bros. and Swinfen, Ltd., 1954.) 12 dollars; 102*s*.

ALTHOUGH, within the confines of the British Isles, there occurs an immense variety of rocks, igneous, sedimentary and metamorphic, as well as many deposits of economic minerals of a diverse character, the number of British text-books of university standard describing these rocks and their origins is quite small. Text-books by authors who have studied rocks in other countries, and whose attitude to the problems involved may differ from that of British authors, should, therefore, have a definite value for British students, as a means of broadening their outlook. Both the works noticed here form useful additions to the range available.

Messrs. Williams, Turner and Gilbert's "Petrography" forms an excellent introduction to the subject for first- and second-year students, more especially because it deals with the three main rock groups—igneous, sedimentary and metamorphic—within the limits of a text-book of average size. The work is fully illustrated with a large number of figures carefully drawn from selected thin sections of typical rocks, half of which have been chosen from sources outside the United States. As the authors state, previous text-books of this standard have devoted too little attention to sedimentary rocks; but it surely ought not to be necessary to advance as justification for the inclusion of an adequate description of the rocks of this class the fact that in the United States most graduates in geology now enter the petroleum industry.

The second book noticed here is essentially a translation of the first volume of the late Prof. P. Niggli's "Gesteine und Minerallagerstätten", published in 1948. It is a work of a much more advanced character, suitable for honours and postgraduate students. The subject is dealt with against a theoretical background of geochemistry, crystal chemistry and physical chemistry. The fact that it has been prepared by Niggli's colleague, Prof. R. L. Parker, is sufficient guarantee of the adequacy of the translation, which, however, is not literal; but an English version of the original into which has been introduced a certain amount of new material, especially in the sections on crystal chemistry and classification. On the other hand, some sections of the original have been shortened, and the section on geophysics has been omitted on the ground that it has been treated more fully in recent publications in the English language.

The publishers are to be congratulated on the high quality of the printing, paper and binding used in the production of these two books; but it is regrettable that the price is likely to put one, and perhaps both, somewhat beyond the reach of the average university student.

BILE PIGMENTS

Biology of Bile Pigments, including a Review of their Chemistry and a Discussion of Analytical Methods

By Torben K. With. Pp. xiii+523. (Copenhagen: Arne Frost-Hansen, 1954.) 50 kronor.

DURING the past five years there have been published no less than five monographs dealing either exclusively or in substantial part with the bile pigments. The latest of these, "The Biology of the Bile Pigments", is a monumental treatise which contains an account, often in great detail, of most of the major work published on the subject between 1800 and 1953. The result is a valuable book of reference, which, though indispensable to all workers concerned directly with this field, is unlikely to appeal to a wider circle of readers. To the specialist, the list of references, complete with full titles and numbering well over two thousand, will be especially welcome.

The presentation of the subject-matter is very uneven. Some chapters, such as those dealing with jaundice and with the comparative biology and biological significance of bile pigments, are excellent and contain much information of interest not readily available from any other source. The author discusses in detail the earlier view that bile constituents may be secreted into lymph, and presents an excellent case for regarding parenchymatous and obstructive jaundice as lymphogenous in nature. The use of the term 'retention jaundice', however, to cover conditions in which the liver cells are damaged and unable to secrete bilirubin without any associated secretion into the lymph, is likely to cause confusion. According to the more generally known classification of Rich, retention jaundice would be the same as Witt's production jaundice and may be hæmolytic in origin or of the type found in hereditary non-hæmolytic jaundice. It is a pity, therefore, that the author has not seen fit to integrate his new classification within one or other of the earlier schemes of the mechanism of jaundice. The experimental work leading to our theories of the detailed mechanism of the different forms of jaundice is well reviewed and rightly emphasizes that our knowledge in this field is far from complete. The last chapter is full of useful information regarding the occurrence of bile pigments in lower animals and plants and suggests that much might be learned from a more intensive investigation of their fate in species other than the higher mammals. One agrees with the author that much valuable information might accrue from further

studies of bile pigment metabolism in the horse, a species in which urobilinoids are present in the fæces, yet in which the bile apparently contains no bilirubin.

Much of the earlier experimental results concerning amounts of the various bile pigments in the body fluids and excretions might with advantage have been condensed into a table and in some cases omitted altogether except perhaps from the list of references; all too frequently the earlier work was carried out with inadequate methods, and certainly in the case of the urobilinoids the substances were estimated without a pure preparation available as standard. Although Dr. With rightly criticizes these techniques, he still presents the results obtained by them.

The van den Bergh reaction is dealt with in remarkable detail, and although the precise proportions, amounts and concentrations of the various reagents which have been used are important in facilitating a correlation with the result obtained, the thirty-odd pages devoted to this subject make heavy reading, especially with so much in small type. The impartial presentation of the results of various workers sometimes introduces unintentional contradictions. For example, on p. 156 Kitchling and Kuhn are quoted as showing that strong solutions of bilirubin after treatment with the diazo reagent do not follow Beer's Law because of insufficiency of reagent; on the other hand, three pages later there is an account of the work of Bungenburg de Jong, who has shown that the reagent is in good excess. Dr. With's accounts of the research of the last worker are especially valuable to the English reader, for they were mainly published in Dutch or German.

Seven addenda bring the subject-matter up to date and deal with the major works published between 1951 and 1953. One of these has a useful account of Hanson's *in vivo* work on rat livers, with fluorescence microscopy and uranin as an indicator for the biliary tracts. This is interesting work, but Dr. With doubts whether the distribution of uranin is likely to be the same as that of bilirubin. Another of these addenda describes work by Bourrillon, a member of the Polonovski school. This was published as a thesis and has not been generally available. Bourrillon has disproved the view of this group that the direct diazo reaction of certain sera was due to linkage of the bilirubin with globin. The work of Cole and Lathe, who have demonstrated by reversed phase partition chromatography the existence of two polar pigments which give direct diazo reactions, has been adequately summarized and discussed in a page inserted after binding was complete.

This monograph was originally intended to be printed in the United States; but its length prevented this and it has been produced by a Danish publisher in mimeograph on one side of crown quarto pages. The resulting volume, bound simply between boards which measure eleven and a half inches by eight inches, is two and a quarter inches thick, weighs six pounds and is not very manageable. The author's English is excellent, although its phraseology is sometimes quaint; there are innumerable typing errors—no doubt due to a non-English proof reader—but at no point is there ambiguity or obscurity. The figures have been moderately well reproduced and mostly tend to illustrate some of Dr. With's own research. Presumably because of the form of publication, it has not been possible to illustrate some subjects which would have been better understood with a figure—for example, the work on the biosynthesis of the porphyrins. The large pages crowded with type, often small, make for difficult continued reading. The book is not intended for the general reader; it is essentially a book of reference for specialist workers, and for them Dr. With has performed a signal service.

C. H. Gray

ECOLOGY OF FRESHWATER MOLLUSCS

An Introduction to Molluscan Ecology

Distribution and Population Studies of Fresh-water Molluscs. By Dr. Alan Mozley. Pp. x + 72. (London: H. K. Lewis and Co., Ltd., 1954.) 9*s*. net.

THIS slender volume forms the fourth in a series by Dr. A. Mozley on freshwater molluscs, their ecology, control and relation to mankind. In some parts of the world certain species of water snails carry the larval stages of the parasites responsible for the dangerous diseases, urinary and intestinal schistosomiasis, affecting 5 per cent of the human race, and others convey the parasite causing liver rot in sheep; but not all water snails are harmful, and Dr. Mozley is here concerned with the ecology of freshwater molluscs in general. As an authority on schistosome-carrying snails, he is naturally most interested in harmful species; but his experience in Siberia, Africa, Finland and Canada has enabled him to produce a little book packed with useful information and provocative thought on both harmful and harmless species.

In seven chapters he deals with limiting factors in distribution, living conditions, representative populations, dangerous localities, local economy, practical considerations and conclusions. There is also an appendix of four sections, explaining scientific details and methods of work for non-scientific readers. The index is adequate. Fourteen beautiful illustrations, chiefly of lake habitats, are scattered through the text; but unfortunately there is no picture of the snails, and a plate of the chief carriers, such as *Physopsis*, *Biomphalaria* and *Lymnaea truncatula*, would have been helpful.

Dr. Mozley is optimistic that schistosomiasis could be brought under control, since the molluscan hosts are "highly sensitive to conditions in the place in which they live", are a menace chiefly in suburban areas and where dense local populations of snails and humans occur, and can be killed, with their parasites, by treatment with copper sulphate at monthly intervals.

Throughout the book one is reminded of the problem of malaria, and of the importance of Sir Malcolm Watson's insistence on "species sanitation". As in malaria control, the problem is a local one, and it demands first and foremost an accurate knowledge of freshwater snails, their habits and habitats. Beyond that, persistence, planning and foresight are needed. Much good work is being done in Egypt under Dr. A. Halawani, director of the Fouad I Institute of Research and Hospital for Tropical Diseases, Cairo. But man in his ignorance and carelessness has brought about a spread of the disease through the Rhodesias to South Africa, and it is still extending its range. "If preventable, why not prevented?" Dr. Mozley's final words are: "There is work to be done".

N. B. Eales

INTERNATIONAL CONFERENCE ON THE PEACEFUL USES OF ATOMIC ENERGY

THE United Kingdom Government has accepted the invitation which was extended by the United Nations to eighty-four countries to participate in a conference on the peaceful uses of atomic energy, to open in Geneva on August 8 under the presidency of Dr. H. J. Bhabha, director of the Tata Institute of Fundamental Research, Bombay, and secretary of the Indian Atomic Energy Commission. Prof. W. G. Whitman, head of the Department of Chemical Engineering in the Massachusetts Institute of Technology, will be secretary-general of the conference, and in this capacity will serve as an officer of the U.N. Secretariat, assisted by a working party consisting of Ralph J. Bunche and Ilya S. Tchernychev (U.N. Under-Secretaries) and Dr. Gunnar Randers (special consultant to the Secretary-General, Dag Hammarskjöld, in matters relating to the conference).

The conference, which is an outcome of proposals laid before the United Nations by President Eisenhower in December 1953 when he urged the need for international co-operation to apply the benefits of atomic energy to world peace, will be devoted to the presentation and discussion of papers on a number of main subjects related to the peaceful uses of atomic energy (see preliminary announcement, *Nature*, February 19, p. 328). It is intended that subjects will be dealt with and presented only from the scientific and technical points of view.

The United Kingdom Papers Committee, which has been set up under the chairmanship of Sir John Cockcroft, director of the Atomic Energy Research Establishment, Harwell, to integrate the United Kingdom's contribution to the conference, has drawn up a provisional list of papers and authors covering the majority of topics to be discussed. The Committee will be pleased to receive suggestions for titles and authors of additional papers, and communications should be addressed to the Secretary of the Papers Committee. Abstracts not exceeding five hundred words in length must be submitted to the Papers Committee on or before May 1, and the completed papers must be submitted on or before June 15.

The constitution of the U.K. Papers Committee is as follows: Sir John Cockcroft (chairman); Sir George Thomson (Royal Society); Dr. G. H. Daniel (Ministry of Fuel and Power); Dr. J. F. Loutit (Medical Research Council and Agricultural Research Council); Mr. P. Dankwerts (Industrial Group, Atomic Energy Authority); Mr. J. A. Jukes (Atomic Energy Authority); Dr. B. F. J. Schonland, Dr. J. V. Dunworth, Dr. R. Spence, and Dr. J. Gaunt (secretary) (Atomic Energy Research Establishment, Harwell).

It is unlikely that time will permit more than a small fraction of papers to be presented verbally; but all accepted papers will be published in the proceedings of the conference. Owing to shortage of accommodation, it is not certain that authors of papers will be able to attend all the sessions of the conference, even if their paper is accepted for verbal presentation. The final choice of papers will lie with the United Nations Advisory Committee, which is responsible for advising on conference arrangements.

The United Kingdom Government will contribute to the exhibition to be held in Geneva during the conference, and full details regarding it will be announced at a later date.

The plenary sessions of the conference will cover the following topics: (*A*) and (*B*), need for a new power source; (*C*), the role of nuclear energy; (*D*), the building of a nuclear energy enterprise; (*E*), health and safety aspects of nuclear energy; (*F*), production and use of isotopes, and problems relating to large quantities of radioactive substances. The sessions dealing with the need for a new power source will include survey papers on estimated world-power requirements in 1975 and 2000, on the alternative sources of power, and on the needs of individual countries for power and heat. Session *C* will include survey papers on the natural occurrence of uranium and thorium; each nation is being invited to furnish all available data, and the conference organization will make a summary of papers submitted, a few of which will be selected for presentation. Session *D* will deal with the capital investment required for the development of nuclear energy and will include experience with existing plants. Session *E* will consider the biological effects of radiation, including a discussion of human exposures which have occurred and the results of animal experiments, ecological problems arising from selective destruction of a given species in the food web, and the location of power reactors, with special consideration to the widespread dispersal of fission products. Session *F* will include survey papers on the use of isotopes in science and industry, and also on the problems of long-term storage and disposal. Session *G* will be concerned with what may be termed the present state of the art of handling large quantities of radioisotopes and the administrative and legal problems arising in the use of high-level radiation sources; this covers such matters as the training of industrial personnel, industrial safety, workman's compensation, etc.

In addition to the plenary sessions, there will be more specialized meetings devoted to specific topics. Under the heading of reactors, the programme mentions research reactors, power reactors including survey papers on fuel cycles and types of reactor, fast neutron reactors, thermal neutron reactors, and details of the running of prototypes of power reactors.

Sessions on technology are expected to cover such subjects as methods of prospecting for uranium and thorium, chemical treatment of the ores, production of uranium and thorium metal, analytical methods and the production technology of special materials such as heavy water, zirconium, beryllium and its oxide, and graphite. It is also hoped to have survey papers on chemical aspects of nuclear reactors, chemical processing of irradiated uranium and thorium fuel elements and the storage and separation of fission products. Other subjects included under the general heading of technology include the metallurgy of thorium, uranium and their alloys, fabrication of fuel elements, technology of liquid metals and the treatment and disposal of waste.

Reactor physics sessions will deal with equipment and techniques used in measuring cross-sections important for reactor design and the results obtained; selected topics such as neutron decay, certain (n,γ)

or (γ,n) reactions, fission, γ-ray spectrum in fission, measurement of such quantities as the number of neutrons per fission, diffusion length, slowing-down length, transport mean free path and resonance integrals; zero energy, exponential and critical (or model) experiments; reactor calculation techniques and comparison with experiment.

Sessions on reactor chemistry and metallurgy are expected to have survey papers on the fission process and the chemistry of its products, and the chemistry of the heavy elements, especially plutonium and neptunium. The problems involved in studying chemical reactions using highly radioactive materials, and the effects of radiation on materials used in reactors and also on solutions and metals, alloys and semiconductors, are also to be considered.

The biological and medical sessions will deal with such topics as the use of nuclear energy in medicine, for example, for diagnosis, therapy or tracer techniques, and in special public health problems such as the epidemiology of communicable disease, and the availability of rare elements in human nutrition. Genetic effects will also be considered in these sessions, covering both botany and zoology. Sessions will also be devoted to the biochemical and physiological uses of radioactive isotopes; use of nuclear energy in special problems of agriculture and forestry concerning plant genetics, movement of plant nutrients, pests, etc.; environmental mechanisms; and public health, including biological cycles of fission products in land and water organisms.

The topics to be considered in the sessions on the applications of radioisotopes to research and industrial problems include tracers in general research, developments in dosimetry, instrumentation and remote controls, applications of isotopes in process and quality control, and industrial utilization of fission products.

In addition to the specialized papers in the various sessions referred to, there will be a number of evening sessions at which leading men of science will deliver lectures of a more general character; the topics to be discussed will be accelerators for particles, elementary particles, nuclear forces, nuclear structure, the neutron, isotopic dating, uses of radioactive substances in biology and medicine, free radicals and new elements.

EMIL BEHRING AND PAUL EHRLICH*

THEIR CONTRIBUTIONS TO SCIENCE

By Prof. C. H. BROWNING, F.R.S.

Emeritus Professor of Bacteriology, University of Glasgow

Cancer Research

THE first results of Ehrlich's cancer investigations, which started late in 1901, were to demonstrate on an extensive scale the general impossibility of establishing tumours of one animal species in others. He also set about obtaining, in addition to Jensen's tumour, a series of transplantable tumours in mice which should be available for study. By giving a twenty-mark piece for every animal bearing a spontaneous tumour a large number were collected; the majority arose from the mammary gland in old female mice. Subcutaneous grafting in fresh animals established numerous strains, although very many failed to grow. On the analogy of infections, their 'virulence' increased on passage in the sense of the proportion of takes and the rate of growth. A minute study of their biology and structure indicated that the initial survival and subsequent growth of a fresh graft were closely associated with the angiotactic effect on the host's blood vessels. The microscopic structure depended considerably on the rate of growth. In addition to carcinomas, other classes of tumour were also propagated, for example chondro- and osteo-sarcomas. A remarkable observation was the development of sarcoma in a strain of carcinoma and thereafter the successful separation of the two malignant components. The origin of the mixed tumour was attributed to some chemical effect of the carcinoma cells on those of the stroma. At the time, little was known of chemical carcinogens; but later observations presented the picture of what may be a closely analogous phenomenon. This was the production of sarcoma in mice from a phagocytic tissue which had developed in response to particles of a styryl quinoline compound resulting from precipitation of the dye in the tissues by the lymph[1]. Ehrlich approached the problem of acquired resistance to tumours by inoculating mice with a spontaneous tumour of negligible virulence; after 8–14 days, upwards of 50 per cent of the treated animals had become refractory to grafting with a highly virulent tumour, and this state lasted for some weeks or months. Normal tissues produced a similar effect. In spite of many interesting findings, the mechanism of acquired resistance to tumours still remains obscure, however.

The influence of nutritional factors on tumour growth interested Ehrlich deeply. He observed that a mouse tumour inoculated into rats grew vigorously for several weeks, but then receded; also transplants from the original rat to other rats failed to grow. On the other hand, the tumour could be maintained by alternate passages from rat to mouse. The conclusion drawn was that some nutritive material essential for growth is present in mice, but not in rats; hence the resistance of the latter was termed athrepsy. A number of other phenomena were also classed as athreptic; but so far the conception has not proved fruitful for tumour pathology in general. The results of experiments on the chemotherapy of tumours were not published.

Chemotherapy

In 1891 Ehrlich, with Guttmann, published encouraging results in the treatment of malaria with methylene blue. From 1904 onward he concerned himself chiefly with chemotherapy. This work makes great demands on aptitude, patience and material resources, as well as luck (the '4 G's'—from the initials of the German words). His reputation as a scientist stood very high, and Frau Franziska Speyer, in memory of her husband, provided for the building and endowment of the Georg Speyer-Haus, to be devoted to research on chemotherapy, with facilities both for biological and chemical workers. When it started in 1906 there were three chemists and two biologists; soon the numbers increased. Already a very significant success had been achieved with trypan red, which in a single dose sterilized mice severely infected with *T. equinum*, the trypanosome responsible for a disease of horses in South America.

* Continued from p. 575.

The infection in mice assumed a septicæmic form and was invariably fatal in a few days in untreated animals; no other cure was known. The drug was found as the result of trying the effect of a large number of available dyes, among which one of the benzopurpurine series showed slight action. It was poorly soluble, and Ehrlich concluded that slow absorption from the site of injection might impede its action. Accordingly, a series of related compounds was prepared for Ehrlich in the laboratories of his friend, A. v. Weinberg (firm of Cassella); trypan red was the best of these. However, it did not act on *T. brucei*, which is closely related to *T. gambiense*, the cause of African sleeping sickness.

Drugs moderately effective against *T. brucei* were found in the triphenylmethane series, etc.; also, French workers noted that trypan blue, related to trypan red, acted; but these showed no great prospect of chemical development. At this time, Thomas, of the Liverpool School, directed attention to the therapeutic action in trypanosomiasis of the arsenical atoxyl, which Ehrlich had previously discarded, since the strain of trypanosomes then tested was insensitive. He confirmed its therapeutic property and in his hands it proved the starting point for synthesis of a very large series of organic arsenicals, among which was the famous salvarsan. This drug, in addition to being trypanocidal, acted also on various spirochætal infections, including relapsing fever and syphilis. In this disease in man its efficacy enormously transcended that of mercurials, the folk remedy. Ehrlich, from being a scientist of international reputation, became a world celebrity. At the same time, he fell a victim to worries which had not previously threatened his work. For example, in the air salvarsan is readily oxidized to very toxic products; for this reason it was dispensed in single doses in sealed tubes from which air was removed. Also, precise instructions were issued for preparation of the solution in sterile distilled water, neutralization and intravenous injection without delay. Instead of the directions being followed, the drug was often kept for long periods before administration or used when only partially dissolved, or infected water employed. The resulting disasters received wide publicity and Ehrlich was blamed.

In the chemotherapy of experimental trypanosomiasis, the chief phenomena of 'therapeutic biology' were discovered in Ehrlich's laboratory. These are as follows. (1) Variations in therapeutic response as measured by the ratio of the curative dose to the maximum well-tolerated dose. Determining factors are the host's species and individuality, also the parasite's species and strain (including its past history). (2) Immunity reactions of the host during treatment frequently are a factor in cure. (3) Alterations in antigenic constitution of the parasite occur when the course of the infection is a relapsing or a chronic one; new antigens replace the old ones or may become superadded. This is a serious obstacle to effective treatment; because there is, as a rule, little or no cross-immunity between strains of the same species. Such changes may be produced at will, for example in *T. brucei*, by adding a sublethal dose of the antiserum to the parasites *in vitro* and then injecting them into a fresh animal. The parasites of the resulting infection have acquired fresh antigens, that is, a serum-fast (or relapse) strain has developed. The only certainty of maintaining a strain unaltered in its antigens exists where the parasites multiply progressively and become abundant in the blood within a few days after inoculation; at this point, the acme of the infection, they must be transferred to a fresh susceptible animal of the same species and the procedure repeated indefinitely. (4) Acquired drug-resistance may result where treatment fails to cure and relapses are treated with the same drug. Finally, there is no therapeutic response, and when the parasites are transferred to fresh animals the infection resists maximal doses of the same drug. Such drug-resistant strains are, of course, also relapse strains. But drug-resistance can be developed without antigenic change by treatment in successive passages with doses too small to retard the acute course of the infection. Contact of parasites and drug *in vitro* between successive passages may also lead to a drug-resistant strain. Whether acquired drug-resistance is a mutation or an adaptation remains unsettled. Where it develops only very slowly the question would appear to be largely one of definition. (5) Therapeutic interference (known to Ehrlich from 1907, but not published until 1922) consists in one trypanocidal drug (parafuchsin) preventing or reducing the therapeutic action of another (trypaflavin). Other examples of such interference are now known; and a form of biological interference between viruses has of late attracted attention. The mechanism of therapeutic interference is obscure; it is not connected with acquired drug-fastness. For the original case, Albert has suggested that the two substances form mixed micelles.

Later investigations on other infections have not added anything important to the phenomena of therapeutic biology discovered in connexion with trypanosomes[5].

As to the mechanism of action of trypanocidal drugs, practically all the evidence points to their damaging the vitality of the organisms either directly or by derivatives formed in the body. Thus, in the case of the aromatic arsenicals, while the pentavalent arsonic acid compounds (atoxyl series) are almost innocuous to the trypanosomes *in vitro* and the trivalent arsenobenzole (for example, salvarsan) is not very toxic, the corresponding trivalent arsenoso compound or arsenoxide (mapharside) is a most potent poison. There is also experimental evidence that the pentavalent form yields the arsenoxide *in vivo*; therefore, most probably this is the active substance in the body. Ehrlich originally chose the arsenobenzole for therapy on account of the high toxicity of the arsenoxide for mammals; but it is not certain if this preference was fully justified. He postulated the fixation of the haptophore group of the drug by receptors of the parasites (chemoceptors). The fact that drug-resistant strains fix less of the drug than susceptible strains is strong evidence for this. Resistance would thus be due to a lessened affinity for the drug from loss or diminution of the corresponding chemoceptors by the organisms and not to increased tolerance. Ehrlich found that atoxyl-fast trypanosomes were susceptible to a certain drug of the arsenobenzole class, arsenophenylglycine, but could be rendered resistant to the latter also. Therefore, he supposed that the acid side-chain which this compound possesses must act as a second haptophore and so increase its affinity for the organisms.

King, however, has recently brought evidence which emphasizes the influence of physical-chemical factors. He found that the corresponding arsonic acid also acted on an atoxyl-fast strain *in vivo*. Accordingly, he studied the action of a series of the

arsenoxides on the trypanosomes *in vitro* and correlated the results with the physical-chemical behaviour of the compounds. The following were salient findings: the arsenoxide of arsenophenylglycine, which is highly ionized and will travel in water, also phenyl arsenoxide which lacks a hydrophilic group apart from the arsenical and so will travel at a lipoid–water interface with phenyl in the lipoid, both act equally on normal and on atoxyl-fast strains. On the other hand, the arsenoxides of atoxyl, its acetyl derivative, etc., which act much more strongly on normal than on atoxyl-fast parasites, are probably substantive for certain chemically polar constituents which fix trypaflavin, since resistance to trypaflavin and to arsenicals of the atoxyl type is identical. King concludes that there is no evidence that differences in chemical reactivity among these various arsenicals exist and so play a determining part. In all probability, therefore, the substances differ in the first phase of their action, and the ultimate nature of the arsenic receptor is unknown. Ehrlich suggested that the effect of arsenic might be exerted on sulphydryl groups of protoplasm; and Voegtlin *et al.* showed that glutathione neutralized the trypanocidal action of trivalent arsenicals both *in vivo* and *in vitro*. But no further clarification has been possible and no chemoceptors have been identified chemically.

Ehrlich thought of the molecule of a chemotherapeutic agent as being like a toxin, provided with a toxophore group, as well as a haptophore, but did not particularize further. His aim was to increase the 'parasitotropic' properties of drugs, while diminishing the 'organotropic' or, in other words, to find substances with selective toxicity. Nowadays, when the importance of enzymes for vital processes has become prominent, it has been suggested that the drug dislocates such processes. One way in which this may occur is by introducing an imitation or perversion, so to speak, of an essential substance, which is accepted by the parasite and incorporated in its metabolic apparatus, and so blocks the action of some enzyme. This shifts the problem to 'first find your enzyme', which so far has proved a very difficult one. Another recent suggestion is that some drugs act as chelating agents and so deprive the parasites of essential trace metals. This would be a form of Ehrlich's athrepsy; and it is known that the multiplication of *Pl. berghei* and *T. congolense* can be prevented by diets which sustain the life of the host.

The chemotherapy of spirochæte infections was closely associated with that of trypanosomiasis. *Spirillum minus*, a small non-pathogenic organism found in mice, was investigated and found to be refractory to most known trypanocidal drugs, but susceptible to salvarsan. With this lead the antisyphilitic property was discovered. With *Tr. pallidum* there was little evidence that acquired resistance to arsenical drugs would be a serious danger. As an antisyphilitic, salvarsan has now been superseded, at least temporarily, by penicillin, which is much less poisonous. It is of interest that penicillin has no trypanocidal action. The relapsing fever spirochætes also are often susceptible to salvarsan; but resistant strains are met with. Such an occurrence raises the question whether a drug-fast strain has been produced by treatment in the field, and this problem arises in connexion with trypanosomiasis also. But it must be borne in mind that mass treatment may eradicate the susceptible infections and so lead to an apparent increase of cases harbouring less susceptible strains. There is ample evidence that such "ferox" strains, as Ehrlich called them, arise independently of specific treatment. The leptospiroses are unsusceptible to known chemotherapeutic agents. He was not very hopeful about the prospect of finding chemotherapeutic agents for systemic bacterial infections, and it is strange to recall that the synthesis of sulphanilamide was published in 1908.

Ehrlich's method in the contrivance of chemotherapeutic drugs was first to find by trial a compound showing some degree of the desired action, and then to prepare structural variants with the view of decreasing toxicity for the host, while relatively increasing that for the parasite. Accumulated experience has now furnished much information on the likely effects of introducing substituent groups into the molecule of such drugs, but generalizations of wide applicability are still not numerous. In the absence of a far deeper knowledge of the biochemical differences between the metabolism of hosts and parasites, this has so far proved the most promising approach. A more rational, planned attack on the problem would require meanwhile, as King has aptly put it, the co-operation of agents with powers like those of Clerk Maxwell's "demons". What would be the position of chemotherapy to-day without Ehrlich? He alone in his time had the profound knowledge both of biology and chemistry, as well as the enterprise, to apply chemical means to the attainment of purely biological ends. He seemed to sense the presence of a rich treasure where no one else suspected its existence. It is fairly safe to guess that without this one man a fruitful branch of pharmacology and a profitable industry, as well as an era of immense amelioration of human and animal diseases, would have been long delayed.

Chemistry

Ehrlich was continually engaged in chemical investigations. While there was, as a rule, a biological aim in view, a number resulted in valuable contributions to pure chemistry. The usual procedure was to find some chemically highly reactive compound and to explore its synthetic capabilities, especially in the direction of intensely coloured products, or else he probed the constitution of a substance by examining its behaviour with reagents which would identify the presence of particular atom-groups. His apparatus consisted merely of test-tubes, a Bunsen burner and a copious collection of compounds, reagents and solvents. But to these was brought an enormous knowledge of organic chemical literature, particularly in all that concerned dyes, their intermediates and methods of synthesis. When a lead was obtained, the help of chemical specialists was sought and he had a preference for those with experience in industry, where good yields are reckoned of importance. The following is a selection of Ehrlich's chemical work which proved of outstanding importance. The diazo reaction of urine consists in a red coloration on addition of diazotized sulphanilic acid and ammonia. A positive result is got in cases of fever, especially enteric, but not with normal urine. The reaction has been traced to bilirubin and other pyrrole compounds and has found an important application in the investigation of hæmopyrroles. The dimethylaminobenzaldehyde reaction of urine is a brilliant cherry-red coloration on adding a solution of the reagent in dilute hydrochloric acid; it is given

in various febrile states and is due to the pyrrole component in urobilinogen. A coloured product is also given with indole and is a delicate indicator for its formation in bacterial cultures. Reactions of aromatic nitroso compounds: (1) with acid chlorides highly reactive products are formed; for example, that from benzoyl chloride and nitroso-dimethylaniline along with a solution of *m*-toluylenediamine in the cold at once produces toluylene blue; (2) with reactive methylene groups; for example, nitroso-dimethylaniline and benzyl cyanide condense readily, and the product is split by mineral acid to yield benzoyl cyanide; this provides a method for obtaining ketones from the corresponding methylene compounds. Similarly, the preparation of the aliphatic triketopentane, a very powerful reducing agent, was achieved. Also the use of the reaction helped in determining the constitution of atropine and cocaine. The reaction of azonium bases with compounds containing free or substituted methylene groups yields highly coloured compounds; for example, flavindulin and deoxybenzoin produce a base the salt of which is at first blue, but on standing turns orange-red. The Ehrlich–Herter reaction with 1:2-naphthoquinone-4-sulphonic acid consists in the formation of coloured products on condensation with aromatic mono- or di-amines; a concentration of one part of aniline in one million can be detected: compounds containing reactive methylene groups (also methyl groups) produce coloured salts, which act as mordant dyes; in these the 4-sulphonic acid group has been replaced by the aromatic residue. The rhodamine dyes, also nile blue and other oxazine dyes, were developed industrially as the result of Ehrlich's suggestions for compounds which he required for biological researches. Aromatic compounds of arsenic were prepared in considerable variety by Michaelis about thirty years before Ehrlich's work. Still earlier, Béchamp made what he took to be an anilide of arsenic acid. But the field was largely neglected, except that a sodium salt of Béchamp's compound was manufactured and placed on the market as a drug under the name of atoxyl, which was little toxic in relation to its content of arsenic. It appears that Ehrlich found atoxyl could be diazotized and so must have a free amino-group. Along with Bertheim, its constitution was established as the salt of *p*-aminophenyl arsonic acid ($NH_2.C_6H_4.AsO(OH)_2$). This opened up wide synthetic possibilities: according to the degree of reduction of the arsenic atom, in addition to the arsonic acid series, arsenoso (—AsO) and arseno (—As=As—) derivatives can be prepared. Some thousands of such substances have been made.

Pharmacology

Relations between the constitution of chemical compounds, their distribution in the body and action on the tissues were an abiding interest for Ehrlich and, as has been seen, most of his work involved aspects of the problem. In order to act, a substance must be fixed—its haptophore groups must find fitting receptors and then its ergophore (toxophore) groups can operate; both groups are determined by their chemical and physical characters. A number of important studies on these lines have not been dealt with so far. An early work on the passage of fluorescein into the aqueous humour after paracentesis of the anterior chamber and subcutaneous injection of the dye was significant for elucidation of the circulation of the intraocular fluids. In an investigation of the febrifuge quinoline derivative, thallin, the distribution of the drug in the tissues was demonstrated by means of ferric chloride, with which it yields an intense green colour capable of being fixed with mercuric chloride. Thallin is stored in the fatty tissue and, as this is poorly oxygenated, the drug is preserved from oxidation. It is noteworthy that as early as 1886 Ehrlich proved the antipyretic property of the drug in *sick* animals—rabbits rendered febrile by infecting their skin with streptococci. He investigated staining of the central nervous system *in vivo*; it was demonstrated that generally lipotropism and neurotropism are manifested in parallel, the phenomenon being regarded as analogous to the Stas–Otto process. In enunciating the principle, Ehrlich was the forerunner of Overton and Meyer. The importance of physical factors in staining was clearly brought out by showing that an alcoholic solution of cyanin when diluted with isotonic saline does not stain the central nervous system; but when blood serum is the diluent the dye is more finely dispersed and then staining occurs. Ehrlich discovered that cocaine, in addition to its local anæsthetic action, produces a remarkable diffuse foamy degeneration of the liver cells. He therefore investigated the correlation between the two properties in a series of cocaine derivatives, and observed that the liver changes are produced by a number of the compounds which are devoid of anæsthetic action.

The above is an outline of Ehrlich's chief contributions; but much of importance has necessarily been omitted. In every field in which he worked, the facts discovered, the methods devised and the theories which he formulated are still dominant.

[4] Browning, C. H., Gulbransen, R., and Niven, J. S. F., *J. Path. Bact.*, **42**, 155 (1936).
[5] Browning, C. H., *Ann. New York Acad. Sci.*, **59**, 198 (1954).

THE INDIAN AGRICULTURAL RESEARCH INSTITUTE

By Sir JOHN RUSSELL, O.B.E., F.R.S.

THE Indian Agricultural Research Institute celebrated its golden jubilee during April 1–4. Its foundation in 1905 was facilitated by a gift of £30,000 by an American, Mr. Phipps, to the Viceroy, Lord Curzon, who was anxious to extend the application of science to the production of food in India. This was not a new venture. The Famine Commission of 1880 had made a beginning, and nine years later Dr. J. A. Voelcker was invited to visit India, study the problems on the spot and advise thereon; his report was very shrewd and able, though it was years before he was given the credit he deserved for it. At that time agricultural improvement was considered to be chiefly a matter for chemists, and Dr. Voelcker's assistant, J. W. Leather, was appointed to do what he could. Before long, problems arose that lay outside the realm of chemistry: sugar cane diseases were causing serious losses in Madras, and in 1898 Dr. C. A. Barber was brought over from the West Indies to deal with them. He very wisely adopted the method, not then in common use, of overcoming disease by breeding resistant varieties, and he was so successful that the whole current of Indian agricultural science set for many years in the direction of plant breeding. In 1901 another Famine Commission was set up and was able to insist more

strongly than its predecessor on the necessity for fostering agricultural research; this was fully accepted by Lord Curzon; the agricultural departments were strengthened, and Mr. Phipps's gift made possible the Central Experiment Station.

It was established at Pusa in Bihar, an interesting district at that time as much indigo was grown there and the planters were feeling the competition of the synthetic product. They had their own research organization, but it was too small, too late, and wrongly organized; the crop had to be abandoned. Pusa was better organized from the start: its staff included J. W. Leather as chemist, A. Howard and his gifted wife Gabrielle, née Matthei, both able botanists, she exceptionally good; E. J. Butler was mycologist, and M. Lefroy entomologist. All did valuable work. Leather's was perhaps the least known; it was on the water requirements of plants and on soil moisture and received less attention than it deserved. The Howards had available to them the very useful collection of wheats at the Cawnpore Experiment Station started by W. H. Moreland and extended by J. Haymon and later by Bryce C. Burt; one or both of the Howards had the artist's eye for picking out suitable parents, and before long Pusa 4 and Pusa 12 were widely and successfully grown in the United Provinces and the North West Frontier Province. The aim at the time was to produce in a bad season enough wheat to satisfy home requirements; this meant a surplus in a good season which could be exported to Britain. The plant breeders therefore had in mind the requirements of British millers. Rust-resistant linseeds and wilt-resistant pigeon peas were also bred. Breeding of sugar cane varieties was systematized at Coimbatore by C. A. Barber, and the work was continued by T. S. Venkataraman; the Station was joined with the Imperial Institute in 1931 and remained so until recently.

Pusa had several disadvantages: it was very isolated, which is always bad for the staff of a research institute, and it was not exempt from earthquakes. One came in 1934 and damaged the main building beyond repair. It was wisely decided to transfer the Institute to a site near New Delhi. A thousand acres of land was acquired and some very fine laboratories were set up: the new Institute was opened in November 1936 by the Viceroy, Lord Linlithgow. The ceremony was unforgettable; I was among the guests, and kept in touch with the Institute in after-years; on my last visit four years ago it was a great pleasure to see how well the high hopes expressed on that opening day had been fulfilled.

The present director, Dr. B. P. Pal, has done valuable work in breeding wheats resistant to rust and loose smut. India's wheat belt is in the north, but as rust is worst in the hills Dr. Pal has bred varieties suitable for use there. All three rusts occur—black, yellow and brown; varieties showing good field resistance to each have been produced, but none is yet resistant to all three. Varieties of potatoes resistant to late blight have been produced. The entomological staff is making some interesting investigations on the biological control of insect pests. Good work on soil colloids was done by the previous director, J. N. Mukherjee; the well-known Soils Department is in charge of S. P. Raychauduri. In the Agronomy Department under T. J. Mirchandani a good dairy herd has been built up, giving an average milk yield of 600 gallons per lactation—which is far in excess of the usual quantity in India. Co-operative fertilizer trials in different parts of India are also made.

The Institute's agricultural extension work in the Delhi villages promises to yield valuable results; India's great problem hitherto has been to get the peasants to adopt the improvements devised at the experiment stations. It has not been entirely a matter of ignorance: there have been serious practical difficulties which this extension work will reveal and ultimately, it is hoped, overcome.

A valuable feature of the work from the outset has been the training of postgraduate students to fill the numerous posts created by the Planning Commission and other development organizations. A hostel has been built to accommodate a hundred of them.

The contributions of Indian scientific workers to the advancement of their respective subjects are not so well known outside India as they should be, and it is very desirable that steps should be taken to summarize them in easily accessible monographs. A beginning was made in 1949, when Dr. P. E. Lander, formerly principal of the Punjab Agricultural College, produced "The Feeding of Farm Animals in India"; this was followed by "Dairying in India", by J. N. Warner, of the Allahabad Agricultural Institute, and by "Animal Nutrition Research in India", by Dr. K. C. Sen, director of the Indian Dairy Research Institute at Bangalore.

The Institute has a great record of valuable service rendered to agricultural science in general and to India in particular: a record of which its members can be justifiably proud. It has an able and enthusiastic staff, and all their colleagues and friends elsewhere will wish them a happy and prosperous future.

OBITUARIES

Sir Godfrey Thomson

By the death of Sir Godfrey Thomson at Edinburgh on February 9, education and educational psychology have suffered the loss of an outstandingly vivid personality.

Born in Cumberland in 1881 and educated from early years at Newcastle, Godfrey Hilton Thomson to the end of his life was recognizably of that part of England that lies between Tyne and Tweed. At Armstrong College (now King's College), Newcastle upon Tyne, he graduated B.Sc. with distinction in mathematics and physics, a postgraduate fellowship allowing him to study at Strassburg under Ferdinand Braun and gain a doctorate in physical science. There his natural talent for geometry also found inspiration from K. T. Reye; but for certain turns of circumstance he might well have become a geometer. As it was, the Queen's Scholarship upon which he had entered Armstrong College exerted a long-range effect, since one of its provisions had been that the holder should teach for a number of years. Thus Thomson became an assistant lecturer in education in his old College, an experience which, together with earlier experience as a pupil teacher, gradually transferred his interests towards the psychology of education. This transition is marked by some papers dealing with psychophysical methods. A long vacation spent in the laboratory of C. S. Myers at Cambridge and some statistical contact with Karl Pearson played a further part in fixing the lines of his career. In later life he claimed to be a Pear-

sonian; perhaps Aristotelian might have been the more exact description.

It is probable that his final orientation was determined at the time, and by the occasion, of the well-known controversy, now almost forty years old and somewhat outdated, between him and C. Spearman, concerning the latter's theory of the general and the specific factors that enter into mental ability and are presumed to explain certain properties of the correlation tables derived from test scores. Thomson's own theory, antithetical to Spearman's, was a many-factor sampling theory; but he always preserved a mind open to various later explanations. His mature views are to be found in his book, "The Factorial Analysis of Human Ability", published in 1939.

In 1920 Thomson was appointed to the chair of education at Newcastle, a post which he held for five years, one session being spent in America, where he was always *persona gratissima*. It was during these years that he devised the Northumberland Tests, designed to select children for the advantages of free secondary education. His motive here, as always, was the securing of justice for all classes of the community.

In 1925 he was appointed professor of education in the University of Edinburgh and director of Moray House Training College, an arduous double office which he held until his retirement in 1951. It is remarkable that in spite of the exorbitant demands of administration and of numberless extraneous committees, he still found time to write papers and books. During this period the Northumberland Tests evolved into the Moray House Tests. Characteristically, he refused to accept personal benefit from these, establishing a trust which administered the proceeds towards educational research.

In the two great surveys, in 1932 and 1947, of the intelligence of a complete age-group of all Scottish children, with sociological and other implications, Thomson was chairman of the Mental Survey Committee. Many other chairmanships and secretaryships, of the Committee of Sociology under the Colonial Research Council, of the Twelfth International Congress of Psychology, the British Psychological Society, the Psychology Section of the British Association and so on, make it very apparent that Thomson, a man of pre-eminent public spirit, never spared himself.

A knighthood was conferred upon him in 1949, the culmination of many distinctions. These were worn so lightly that in his presence they were forgotten. Both personally and as an educationist he was known and respected throughout the world; tall, spare-built, alert of glance and quick of speech; forthright, endlessly generous and sympathetic. His work remains and will be remembered; but still more one will remember the man. A. C. AITKEN

Prof. C. O. Bannister

BY the death on February 22 of Charles Olden Bannister, professor emeritus of metallurgy in the University of Liverpool, at the age of seventy-eight, the teaching and practice of metallurgy loses one of its few remaining links with the closing years of the past century, when such far-reaching changes were taking place in regard to what should constitute the curricula of courses for students in that branch of technology. In fact, metallurgy, as a subject, apart from the operations of smelting and recovery, was only just beginning to be recognized as an essential adjunct to successful engineering practice. In this rapidly widening conception of what metallurgy should stand for, Bannister had played a distinguished part.

With a sound basis of practical chemistry before going to the Royal College of Science in 1896, he had there the unique advantage of coming under the direct tutelage of Prof. W. A. Tilden and a brilliant group of lecturers and demonstrators which included William Palmer Wynne, Martin O. Forster and J. S. S. Brame, all of whom achieved distinction in wider fields in later years. Electing to take the associateship of the Royal School of Mines in metallurgy, Bannister then came under the inspiring influence of Roberts-Austen, whose teaching and researches had already pointed the way to the future scope of metallurgy. After heading the list in his year (1899), with the award of the Bessemer Medal, he remained at the School as an instructor in assaying, first under the professorship of Roberts-Austen (until his death in 1902) and then under his successor, Prof. William Gowland. During this period, when he was closely associated with the late W. H. Merrett, he received the postgraduate award of an 'honours' associateship. Then, in 1903, the opportunity came to transfer his activities to the City of London where, a few years previously, the considerable enlargement of a very old city foundation in Aldgate had led to the creation of the Sir John Cass Technical Institute. There, as head of the Metallurgical Department, Bannister built up, during the next sixteen years, what became an outstanding school of metallurgy in the Metropolis.

During his tenure of this post Bannister was also closely associated, as a consultant in Westminster, with the late F. W. Harbord (a School of Mines man of an earlier generation) and with the late E. F. Law (one of his own fellow-students). This association brought him into intimate contact with the varied metallurgical problems with which practising engineers were being confronted in those days, when there were but few to whom they could turn for help and advice. During the First World War (1914–18) Bannister was responsible for a variety of work for the British and Belgian Governments, and he also served as a war-time lecturer at the Royal School of Mines. Then, in 1920, came his appointment as the first occupant of the chair of metallurgy in the University of Liverpool, which he continued to hold with distinction until his retirement in 1941. The Department of Metallurgy was, at that time, unique in being within the Faculty of Engineering. This ensured that its students received tuition both in mechanical and electrical engineering. Moreover, Prof. Bannister arranged that all engineering students should attend courses in metallurgy, particularly of iron and steel. Courses were arranged for naval architects and marine engineers to cover matters such as corrosion and the metallurgy of bearing metals. From time to time he was called as an expert witness in law cases of importance and at times in association with Horatio Ballantyne. During the tenure of his professorship at Liverpool, he had been dean of the Faculty of Engineering from 1924 until 1928 and again from 1935 until 1938.

Bannister undertook to revise, in step with rapid progress, certain metallurgical text-books having an established prestige—Gowland's "Metallurgy of the Non-Ferrous Metals", Sexton's "Metallurgy" and Lunge and Kean's "Technical Methods of Chemical Analysis". He was also the co-author, with H. Garland, of "Ancient Egyptian Metallurgy", and he

also wrote of ancient bronze implements (see *Nature*, 116, 786; 1925).

Prof. Bannister was a member of many technical institutions and societies—to which he had made numerous contributions—such as the Institution of Mining and Metallurgy, the Iron and Steel Institute, the Institute of Metals (of which he was an original member), the Society of Chemical Industry, and the Liverpool Engineering Society. He was a Fellow of the Royal Institute of Chemistry. Of his many awards, his early successes at the School of Mines have already been mentioned. The Edward Matthey Prize for research followed in 1902, and in 1903 he became a Carnegie Scholar of the Iron and Steel Institute, while in 1912 he was awarded the Consolidated Goldfields of South Africa Gold Medal by the Institution of Mining and Metallurgy, and in 1919 the Bessemer Premium of the Society of Engineers.

Those of us who had enjoyed his friendship from the very early days at South Kensington have always had happy memories of his ever-cheerful outlook and genial personality and a great admiration for his work, both as a teacher and as a practitioner. In these spheres his approach was always characterized by a quickness off the mark and by a directness which left no doubt that he had clearly grasped the essentials of any problem or situation with which he might be faced. His judgments were both shrewd and sure.

Prof. Bannister is survived by his widow, a daughter and a son. S. W. Smith

NEWS and VIEWS

Physical Chemistry at King's College, London: Sir Eric Rideal, M.B.E., F.R.S.

Sir Eric Rideal retires at the end of the present session from the chair of chemistry in the University of London which he holds at King's College. He succeeded the late Prof. A. J. Allmand in 1950. During his tenure of office, Sir Eric has materially strengthened the interests of physical chemistry at King's College, particularly at the postgraduate level. His wisdom and wide experience have also been drawn upon in matters beyond chemistry, and although his period in office has been short he has nevertheless brought great benefit and distinction to the College in many ways. He will leave behind many friends. His earlier associations with the University of Cambridge and later with the Royal Institution, as well as his scientific contributions to colloid science and surface chemistry, are well known. His retirement removes from the sphere of academic chemistry one whose scientific work has attained international recognition. The subject of colloid science which he did so much to create and develop will be carried on very largely by the great number of physical chemists throughout the world who had the privilege of working under his direction and inspiration. During the past five years, Sir Eric has also held numerous other offices, including those of president of the Chemical Society and chairman of the Advisory Council on Scientific Research and Technical Development of the Ministry of Supply.

Prof. D. W. G. Style

Dr. D. W. G. Style, who has been appointed to succeed Sir Eric Rideal, was educated at Epsom College and King's College, London. He worked under the late Prof. A. J. Allmand and afterwards under Prof. M. Polanyi at the Kaiser Wilhelm Institut, Berlin. Since that time, Dr. Style has been at King's College, London, where he now holds a readership. He has made notable contributions to physical chemistry in the fields of photochemistry and spectroscopy. During the Second World War, Dr. Style was seconded for work with the Ministry of Supply.

Metallurgy at Sheffield: Prof. R. W. K. Honeycombe

It was recently decided that the Department of Metallurgy and the postgraduate school in physical metallurgy in the University of Sheffield should be merged under Prof. A. G. Quarrell, who was given the title of professor of metallurgy. Dr. R. W. K. Honeycombe, senior lecturer in physical metallurgy, has now been appointed professor of physical metallurgy. An Australian by birth, Prof. Honeycombe was educated at Geelong College and the University of Melbourne. As a research student under the direction of Dr. J. Neil Greenwood, he studied the metallurgy of hard alloys of the cemented carbide type. During 1942–47 he was a research officer in the Lubricants and Bearings Section, now the Division of Tribo-Physics, of the Commonwealth Scientific and Industrial Research Organization, and did metallurgical work under the general direction of Dr. F. P. Bowden. Much of this work was aimed at the solution of Service problems arising from the War. However, some research of a more fundamental character was done in collaboration with Dr. W. Boas, including a study of the thermal fatigue of metals and alloys which show anisotropy of thermal expansion. In 1947 Dr. Honeycombe left Australia to take up an I.C.I. fellowship with Dr. E. Orowan's metal physics group in the Cavendish Laboratory, Cambridge, and two years later he was awarded the Royal Society Armourers and Brasiers' Research Fellowship. While at Cambridge, Dr. Honeycombe made a detailed study of the development of deformation bands formed during the plastic deformation of metal crystals, and afterwards, in collaboration with Dr. A. F. Brown, did electron microscope work which led to the discovery of the phenomenon of micro-slip. Since his appointment in 1951 to Sheffield, Dr. Honeycombe has had considerable teaching responsibilities in the recently established postgraduate school of physical metallurgy. He has, nevertheless, continued his research on deformation, paying particular attention to the deformation of crystals of solid-solution and age-hardening alloys. He is also studying the properties of thorium and its alloys, and the precipitation of carbides in ferritic steels.

The Coblentz Society: a New Society for Infra-Red Spectroscopy

A new society, the Coblentz Society, has been formed in the United States with the object of furthering work in all the aspects of infra-red spectroscopy and of providing a communication centre and forum for the thousands of scientists, research workers

and teachers in the United States who use infra-red spectroscopy. The Society has been given its name in honour of William W. Coblentz, retired chief of the Radiometry Section of the National Bureau of Standards, Washington, D.C., and pioneer in infra-red spectroscopy. It is not intended that the Society should compete with the existing formal organizations for the analytical and physical chemists, physicists, military specialists and such-like; but rather it will cut across the boundaries that separate the various disciplines so as to provide an informal mechanism by which the people who use infra-red can take joint efforts on common problems. At the Ohio State conference on molecular structure and spectroscopy, held in Columbus last June, Dr. Norman Wright, of the Dow Chemical Co., Midland, Michigan, was appointed chairman of the new Society by the executive board of the Committee on Infrared Spectroscopy. Those interested in joining the Coblentz Society should write to the registrar, Dr. V. Z. Williams, c/o The Perkin-Elmer Corporation, Norwalk, Conn.

United States Committee on Loyalty Requirements in Unclassified Research

In connexion with the recent request by the United States Administration that the National Academy of Sciences should advise the Federal Government on its policy in dealing with relations between questions of loyalty and the awarding of Government grants and contracts in support of unclassified research, a committee has been formed with the following members: J. A. Stratton, vice-president and provost of the Massachusetts Institute of Technology (*chairman*); Robert F. Bacher, chairman of the Division of Physics, Mathematics and Astronomy, California Institute of Technology; Laird Bell, a lawyer who until recently was chairman of the Board of Trustees of the University of Chicago; Wallace O. Fenn, assistant dean of the School of Medicine and Dentistry, University of Rochester; Robert F. Loeb, director of medical service, New York Presbyterian Hospital and trustee of the Rockefeller Foundation; E. Bright Wilson, jun., Richards professor of chemistry, Harvard University; and Henry M. Wriston, president of Brown University.

Specific Gravity of Alcoholic Spirits at 20° C.

Under the authority of the Commissioners of Customs and Excise, tables have been prepared showing the relation between the specific gravity of spirits at $\frac{20°}{20°}$C. (68° F.) and the percentage of ethyl alcohol by weight and by volume, with the corresponding percentage of proof spirit (pp. 35. London: H.M.S.O., 1954; 4*s*. net). The tables have been compiled by Mr. A. F. Weiss, of the Government Chemist's Department, Liverpool, and are based on data from existing tables at 60° F., issued by the Commissioners in 1916, together with the values for the thermal expansion of ethyl alcohol given by the United States Bureau of Standards (*Bull.*, **9**, 424; 1913). The choice of 20° C. has been made because this temperature is now commonly accepted as a standard in analytical work; it is emphasized in the preface to the tables, however, that they merely supplement and do not supersede the "Official Spirit Tables" based on 60° and 80° F. The new publication contains four tables, the first of which relates the specific gravity in air at 20° C. (relative to water at 20° C. as unity) to the percentage of proof spirit and the percentages of alcohol by weight and by volume; the range 100–0 per cent is covered in 2,100 steps. The other three tables refer to dilutions by volume of two, three and four times, respectively; each contains three columns showing the specific gravity after dilution, the corresponding proof strength before dilution and the percentage of alcohol by volume before dilution.

Storage Equipment and Methods in Libraries

A handbook on "Modern Storage Equipment and Methods for Special Materials in Libraries" (pp. 32; 1955; 2*s*. 6*d*.) has been issued in connexion with an exhibition of such equipment and methods held in the Council Chamber of the Library Association during January 11–12. It has been prepared by R. L. Collison, from whom it is obtainable (at 7*a* Worsley Road, London, N.W.3), and contains a foreword by J. H. Davies. It includes notes on the handling of different types of material, including atlases, films, film strips, gramophone records, lantern slides, maps, microfilms, news clippings, newspapers and pamphlets, arranged alphabetically; there is also information useful to the research worker who has collected such materials, as well as to the librarian. Besides references under the particular headings, the handbook contains a general bibliography and a directory of advertisers and suppliers of the equipment recommended.

Paper Chromatography of Plant Viruses

Relatively little has been done on paper chromatographic methods for the identification and isolation of viruses. H. W. J. Ragetli and J. P. H. Van Der Want (*Proc. Koninkl. Nederlandse Akad. Wetens.*, **57**, No. 5, Ser. C. 621; 1954) have now reported in some detail on methods they have found useful for the chromatography of tomato mosaic virus on filter-paper strips with water, various concentrations of sodium chloride, acetate–acetic acid buffer solutions, and an acetone–water mixture, respectively, as solvents. Attempts to identify the presence of tomato mosaic virus with a spot that strongly absorbed ultra-violet of about 265 mμ wave-length in the chromatograms were unsuccessful. It has thus far been possible to locate the virus only by inoculating *Nicotiana glutinosa* with extracts prepared from zones cut from the paper strips. The method is considered to be promising as a simple test for the estimation of certain impurities in purified virus preparations and for the preparation of viruses for electron microscopy from low-speed centrifuged sap of diseased plants.

Diatom Flora of Sweden and Finland

The fourth part of the extensive diatom flora "Die Diatomeen von Schweden und Finnland" (in German), by Astrid Cleve-Euler (*Kungl. Svenska Vetenskapsakademiens Handlingar*, **5**, No. 4, 1955; Stockholm. 62 Kr.), relates to the Biraphideae, that is, organisms of the affinity of species such as *Navicula*, *Pinnularia*, *Cymbella*, etc., both living and fossil species being described and illustrated, and localities enumerated. The work is essentially taxonomic in its aims and presentation, and contains no general discussion.

Guinier-type X-ray Camera

A recent Harwell report by R. W. M. D'Eye (A.E.R.E. *C/R* 1524, available from H.M.S.O., London) describes the construction of a Guinier-type

X-ray focusing camera, as developed by Prof. G. Hägg, of the University of Uppsala. This camera, which is probably the first of its kind to be built in Great Britain, has two major advantages over the Debye–Scherrer type of camera: the background is much less intense, so that the photographs are much sharper and weak lines are readily seen; and the errors in determining the Bragg angle θ are much smaller at low values of θ, the major source of error, the absorption error, being almost entirely eliminated. This is of particular importance in indexing photographs of low-symmetry structures; indeed, there are instances in which conventional cameras fail entirely, and a Guinier-type camera is indispensable. A recent example of this is a uranium oxide phase which appeared amorphous to an ordinary camera, but gave a fully indexable picture with the Guinier. The Harwell camera was constructed in the workshops of the Atomic Energy Research Establishment, at a cost of roughly £200.

Year-book of the Textile Institute for 1954–55

The year-book of the Textile Institute for 1954–55 (pp. 248. Manchester: Textile Institute, 1955; 15*s*.), besides giving many of the features of the previous six issues, such as lists of members and of textile and allied organizations, Institute committees, sections and branches, etc., contains details of the changes in the Institute's design competitions which take effect this year. Information about the Institute's examinations and scholarships is also included, as well as lists of the Mather Lectures, Inaugural Lectures and Emsley Lectures, and details of the Institute's publications (including text-books). In addition, the year-book gives a list of trade and technical periodicals held by the Institute, and two useful bibliographies—one of introductory textile literature, and the other a classified list of books on textile subjects, mostly books published since 1945. There are also lists of films of textile subjects, indicating the sources from which they can be obtained, and of standard methods of testing for textiles, in which those which have been published as British Standards are distinguished.

National Science Foundation, Washington, D.C.: Fellowships for 1955–56

The National Science Foundation, Washington, D.C., has announced the award of 715 pre-doctoral graduate fellowships and 70 post-doctoral fellowships in the natural sciences for the academic year 1955–56. Of the former, 255 fellowships have been made to first-year students, 291 to students in their intermediate years, and 169 to those in their last year. The distribution among subjects is as follows: chemistry, 167; physics, 151; engineering sciences, 107; mathematical sciences, 52; zoology, 50; biochemistry, 35; earth sciences, 30; psychology, 27; microbiology, 20; botany, 16; agriculture, 14; medical sciences, 11; genetics, 10; astronomy, 9; biophysics, 8; anthropology, 5; and general biology, 3. Of the post-doctoral awards, 26 have been made in the life sciences, 15 in chemistry, 15 in physics and astronomy, 11 in the mathematical sciences, 2 in the engineering sciences, and 1 in the earth sciences. All the awards are tenable at any accredited non-profit educational institution of higher learning in the United States or abroad. The pre-doctoral fellowships are worth 1,400 dollars for those in their first year, rising to 1,800 dollars for those in their last year of graduate study, and post-doctoral fellowships are worth 3,400 dollars. The fellowships include additional allowances for dependants, tuition and other normal expenses.

Metropolitan-Vickers Postgraduate Engineering Bursaries

Metropolitan-Vickers Electrical Co., Ltd., of Trafford Park, Manchester, has endowed four postgraduate bursaries in electrical and mechanical engineering, each worth £400 a year, in the University of Manchester; two of these bursaries will normally be tenable in the Faculty of Technology of the University at the Manchester College of Technology. The Company has also endowed three similar bursaries tenable in the Mechanical and Electrical Engineering Departments of the Imperial College of Science and Technology, London. A particular purpose of these bursaries is to encourage graduates in physics and mathematics to undertake postgraduate study or research in engineering in preparation for entry into the electrical industry.

British Society for Research on Ageing

The following have been elected officers and members of the executive committee of the British Society for Research on Ageing: *Chairman*, Sir Charles Dodds; *Vice-Chairman*, Sir Francis Fraser; *Secretary*, Dr. G. H. Bourne (London Hospital Medical College, Turner Street, London, E.1); *Treasurer*, Prof. P. L. Krohn; *Members of Committee*, Prof. J. F. Danielli, Dr. H. B. Fell, Prof. K. J. Franklin, Prof. P. B. Medawar and Prof. R. E. Tunbridge.

Colonial Service: Recent Appointments

The following appointments have recently been made in the Colonial Service: L. J. S. Littlejohn (chief soil conservation officer, Tanganyika), regional assistant director of agriculture, Tanganyika; J. T. Moon (assistant director of agriculture, Uganda), deputy director of agriculture, Uganda; M. F. H. Selby (chief agricultural officer, Nyasaland), assistant director of agriculture, Nyasaland; A. F. W. Sheffield (deputy director of agriculture, Eastern Region, Nigeria), director of agriculture, Eastern Region, Nigeria; A. J. Fyfe and F. H. Landon (senior assistant conservators of forests, Federation of Malaya), conservators of forests, Federation of Malaya; D. S. P. Noakes (conservator of forests, Federation of Malaya), deputy director of forestry, Federation of Malaya; H. W. Catling, archæological survey officer, Cyprus; S. D. Gangolli, government chemist, Medical Department, Uganda; A. J. Nutten, chemist, Medical Department, Hong Kong; J. R. Charter, specialist (forest botanical ecologist), Federation of Nigeria; E. G. G. Dykes, assistant conservator of forests, British Honduras; Miss A. P. M. Lynam, records officer, Geological Survey Department, Uganda; D. J. Ducker, veterinary officer, Nyasaland; W. Foulston, veterinary officer, Northern Region, Nigeria; B. L. Nestel, veterinary officer, Jamaica; K. Ogonowski, veterinary research officer, Kenya; and F. G. Peers, veterinary biochemist, Federation of Nigeria.

Conference on Production and Utilization of Electromagnetically Enriched Isotopes

A conference on the "Production and Utilization of Electromagnetically Enriched Isotopes" will be held at the Atomic Energy Research Establishment, Harwell, during September 13–16. Several leading

members of the team responsible for the work on stable isotopes at Oak Ridge are attending, while provisional acceptances have also been received from leaders of the separator groups in France, Holland and Denmark. Although a detailed programme has not yet been prepared, sessions will be included on: (1) design and operation of large mass separators; (2) ion source and collector problems especially with high beam current; (3) separation of radioactive materials; (4) chemical aspects of the production work; (5) preparation of isotopic targets; (6) developments in stable isotopes mass-analysis; (7) utilization of electromagnetically enriched isotopes. Much of the meeting will be occupied with problems of the electromagnetic separator itself; but contributions will also be welcomed on applications of stable isotopes, especially those of an unusual type. The emphasis here should be on the principles involved and not on the details of the great variety of techniques which users may employ. On the other hand, the great volume of work on the application of the isotopes of the lighter elements, particularly of hydrogen, carbon, nitrogen and oxygen, which are more economically enriched by other methods, is specifically excluded. Abstracts of papers must be submitted before April 30, and complete manuscripts before June 30. Further information can be obtained from Dr. M. L. Smith, Atomic Energy Research Establishment, Harwell, Didcot, Berks.

South-Eastern Union of Scientific Societies: Congress in Folkestone

THE sixtieth annual congress of the South-Eastern Union of Scientific Societies will be held in Folkestone during April 14–17. The president-elect, Sir Harold Spencer Jones, has had to withdraw, and in his place the new president will be Dr. Russell J. Reynolds, consulting physician in the Departments of Radiology and Electrotherapeutics, Charing Cross Hospital, London, whose address, to be given on April 15, will be on "Cineradiography" and will be illustrated by a film. The section presidents and the subjects of their addresses will be as follows: *Archæology*, Major H. M. Rand (the Saxon shore forts of Kent); *Botany*, Dr. Francis Rose (the flora of Kent); *Geology*, Mr. C. W. Wright (unsolved problems in Cretaceous stratigraphy and palæontology); and *Zoology*, Dr. Maurice Burton (art in animals). Further information can be obtained from the honorary local secretary, T. W. Birch, 3 Shorncliffe Road, Folkestone, Kent.

Announcements

THE Museum of English Rural Life, established some four years ago in Whiteknights Park, Reading, will be formally opened by Sir Keith Murray, chairman of the University Grants Committee, on April 27. Hitherto, the Museum has been occupied with gathering and recording material; it is now to be opened to the general public (Tuesdays, Saturdays and Sundays during the summer; and Wednesdays and Saturdays during the winter).

A SUMMER laboratory course in techniques and applications of the electron microscope, on the lines of those of previous years, will be given during June 13–25 in the Laboratory of Electron Microscopy of the Department of Engineering Physics, Cornell University, under the direction of Prof. Benjamin M. Siegel. Further information can be obtained from Prof. Siegel at Rockefeller Hall, Cornell University, Ithaca, N.Y.

THE British Plastics Exhibition and Convention will be held this year at Olympia, London, during June 1–11. The Convention will consist mainly of papers on the following subjects: polymer structure and properties; expanded plastics; thermoplastics; extrusion; works study; injection moulding; patents; foundry resins; and glass reinforced plastics. Applications for tickets to the Convention should be made to the Manager, British Plastics Exhibition, Dorset House, Stamford Street, London, S.E.1.

A SECOND international conference on the biochemical problems of lipids will be held in Ghent during July 27–30 prior to the Third International Congress of Biochemistry in Brussels. The colloquium will consist of four sections: physical and chemical properties, structures, and methods of separation; metabolism and biosynthesis, and enzyme systems; phospholipids and transport; and miscellaneous biochemical problems. Application forms and further information can be obtained from the secretarial office of the colloquium at St. Jansvest 12, Ghent.

A COURSE on the use of radioisotopes in engineering has been arranged by the British Council in conjunction with the Atomic Energy Research Establishment. The course will be held during June 12–25, the first week being spent at Harwell attending lectures and demonstrations on radioisotopes, and the second week being spent in and around London visiting firms and establishments engaged upon the manufacture of radioisotope equipment and the applications of radioisotopes to particular problems. The course will be limited to fifteen members, and the fee, including accommodation, will be £40. Applications should be made to the local British Council representative or to the Director, Courses Department, British Council, 65 Davies Street, London, W.1.

THE Development Commission is offering a few training grants to British honours graduates for training in research problems in marine or freshwater science, which is designed to fit them for employment either in the Fishery Research Service of the Ministry of Agriculture and Fisheries and the Scottish Home Department or in a marine or freshwater biological research institute. The grants are worth £250–350 a year, with allowances for university fees, etc., and are tenable initially for one year, renewable up to a maximum of three years. Application forms, to be returned by May 20, can be obtained from the Secretary, Development Commission, 6*a* Dean's Yard, London, S.W.1.

A list of new compounds which have been made available for purchase during the past year has been published by L. Light and Co., Ltd., Poyle Trading Estate, Colnbrook, near Slough, Bucks. The list supplements that of the 1954 catalogue and contains a wide range of uncommon reagents which will be of interest to chemists and biochemists who have hitherto had to prepare such substances for themselves. A number of naturally occurring biological substances, including several enzymes, are also listed. The following are examples of the products picked at random from the list: acetochlorocellobiose; aldolase; arginase; 8-azaguanine; 2-carboxy-pyrrole; carnosinase; chondroitin sulphate; coenzyme II; 4-5- and 5-6- diaminouracil sulphate; 2-4-, 2-6- and 3-4- dinitrotoluene; fumaryl chloride; hemicellulose; various methylated hydroxyquinolines; ovomucoid; purine and pyrimidine as free bases; rhodanese; squaline; and tridecyl alcohol.

THE EARTH'S MAGNETIC FIELD AND NUMERICAL WEATHER FORECASTING

At a meeting on "Hydrodynamical Processes in Meteorology and Geophysics", held jointly by the Royal Astronomical Society and the Royal Meteorological Society on February 25, some problems of common interest were discussed. The two principal topics were convection in the earth's liquid core and its possible relation to changes in, or even maintenance of, the earth's main magnetic field, and recent advances in dynamical meteorology which may lead to improvements in weather forecasting by numerical integration of the equations of motion. It was a welcome feature of the meeting that speakers did not confine their remarks to one topic or the other, but made it clear not only that they had an interest in both but that they were also aware of underlying similarities in the problems posed. That meteorologists, geophysicists and astronomers have such common interests was the theme of the opening remarks of Sir Graham Sutton, president of the Royal Meteorological Society. After outlining progress in dynamical meteorology and methods of numerical weather prediction, in which he takes a particularly keen interest, Sir Graham said he hoped this would be the first of a long series of joint meetings of the two Societies.

The first speaker was Dr. R. Hide, who discussed some laboratory experiments he has made on thermal convection in a rotating fluid. Secular variations of the earth's (main) magnetic field are irregular and, by astronomical standards, very rapid. Since they can be shown to result from changes within the earth, perhaps the only plausible hypothesis is that they are related to hydrodynamical processes in the earth's liquid core. Sir Edward Bullard and others have suggested that motions in the core may be convective, the result of radioactive heating. It was in the hope of discovering something about the motions which would result from heating the core (from below) that the experiments were made. As a guide to setting up suitable experiments, the orders of magnitude of term in the equations of motion were estimated, on the assumption that the motion of the foci of secular change reflects corresponding motions in the core. It was found that the dominating terms ought to involve Coriolis and magnetic forces. Thus rotation should play an important part in controlling the motion.

After outlining the results of James Thompson, Exner and Fultz, Dr. Hide indicated some of his own results. The liquid (water) is contained between two cylinders which are rotated, the outer cylinder being heated, the inner one cooled. The motion depends on the rate of rotation and the rate of heating as well as on the dimensions of the cylinders. If other factors are kept constant, the motion at low rotation-rates is such that water spirals inwards at the top, outwards at the bottom. At a critical rotation-rate the motion changes to a different pattern, with a relatively narrow jet of fast-moving fluid executing wave-like oscillations between the two cylinders. The pattern does not change very much with time apart from a slow 'precession', the direction of which is reversed if the inner cylinder is heated and the outer one cooled. With relatively high temperature differences between the cylinders an interesting, quasi-periodic variation in the pattern, known as 'vacillation', develops. With very high temperature differences the motion becomes very unsteady or 'turbulent'. Dr. Hide noted the similarity of these patterns to those shown by large-scale motions in the atmosphere. He did not discuss the application of his results to the theory of convection in the core, and it now appears that the application may be rather less direct than was at one time supposed.

The second speaker was Mr. J. S. Sawyer, who discussed the theoretical basis of numerical weather forecasting. Numerical integration of the equations of motion of the atmosphere has only recently become a practical proposition; but Mr. Sawyer attributed this advance not so much to the advent of electronic computing machines as to the stimulus given by a sufficient network of observations of upper-air conditions. Previous theoretical work has been either qualitative or too idealized. It is still necessary to idealize in order to obtain tractable equations, equivalent to the setting up of 'models' of atmospheric motion, but the essential features must be retained. A notable advance from earlier attempts by L. F. Richardson was made by Charney, who used a 'filtering' process to eliminate rapidly moving, sound-like disturbances from his model atmosphere. By retaining only the large slow-moving disturbances associated with weather, it is possible to devise a stable computing routine which may be completed, electronically, in a reasonable time. The filtering method involves the use of the 'geostrophic approximation' for the relation between wind and pressure gradient, usually a fairly good approximation for average, large-scale motion. This approximation is used everywhere except where it would imply the direct computation of vertical motion. Large-scale ascent or descent of air is very slow and in practice 'unobservable'. It is computed indirectly from the vorticity equation, an application of Helmholtz's theorem.

The simplest model, said Mr. Sawyer, is the so-called 'barotropic' model, which is concerned only with the average horizontal motion of the atmosphere between the earth's surface and the tropopause. More realistic is the 'two-parameter' model in which the dependent variables may be taken as the stream-function of the mean motion (nearly proportional to the height of the mean pressure surface) and the mean temperature, averaged along the vertical. A justification of this choice of parameters is the observed strong correlation between temperatures at different heights. Although vertical motion is eliminated in deriving the two simultaneous equations governing the rates of change of the parameters, it can easily be computed at any stage. Integration is a 'marching process' in the time dimension with steps, to ensure computational stability, of about one hour. At each stage two two-dimensional partial differential equations have to be solved. Numerical integration using grids of some two hundred points takes, on a relatively slow electronic computor, about three hours to yield a twenty-four hour forecast. Mr. Sawyer showed the results of applying this technique in two cases of special interest, one being the occasion of the recent disastrous flooding in East Anglia and the Netherlands. He referred briefly to some problems involved in dealing with still more realistic models. One problem is how to compute changes in humidity and cloud formation, for condensation modifies the

dynamical behaviour, especially as regards detail on a slightly smaller scale than that of the patterns which the two-parameter model reproduces reasonably well. Mr. Sawyer was only able to mention some recent work of his on computing the intensity of 'fronts', which may go some way towards taking these factors into account.

To indicate that oceanographers are keenly interested in problems closely akin to the main topics, Mr. H. Charnock showed a film of experiments by von Arx with a rotating bowl of fluid. Raised boundaries on the concave inner side of the bowl represent the continental coast-lines, the fluid itself the oceans. The fluid is set in motion relative to the rotating bowl by jets of air representing the drag due to the Westerly and Trade winds. It was noticeable how faithfully the broad outline of the main ocean currents is reproduced in the model. The experiment was designed to test the well-known theory due to Stommel and Munk of the wind-driven ocean circulations.

During an interval for discussion, Mr. T. V. Davies described some theoretical work he had done relating to the experiments made by Hide. He gave a formula for the stability of the wave-like pattern occurring at relatively high rotation-rates in terms of the Richardson number and what has been called the Rossby number (the ratio of the relative motion of the fluid to the motion of the cylinders). He also gave a formula, based on earlier work by Lorentz, relating these two parameters. Unfortunately there was too little time to do justice to this interesting, important but rather complicated subject. It is to be hoped that Mr. Davies will be given an opportunity to present his work in detail and that more time will be allotted for its discussion.

The last speaker was Dr. E. T. Eady, who discussed the properties of 'turbulent' transfer in rotating convecting fluids, with applications to the theory of the general circulation of the atmosphere and to the theory of the earth's main magnetic field. His general theme was that the transfer properties of turbulence are not always of a diffusive nature, as is assumed when effective eddy-transfer coefficients are postulated, but are sometimes anti-diffusive in character to the extent that organized patterns may be built up as a result of the transfer. Moreover, the transfer properties depend on the nature of the process which maintains the turbulence against dissipative forces, and the only reliable guide is a theory of the mechanism. Dr. Eady illustrated these points by considering some aspects of the so-called 'general circulation' of the atmosphere. The large-scale 'eddies' (corresponding to depressions and anticyclones) are a form of convection modified by rotation to such an extent that the heat transfer associated with their continued regeneration is in a slanting direction from a heat source in low latitudes to a radiative sink at higher levels in high latitudes. As a secondary feature these eddies also 'transfer' angular momentum. The nature of this transfer, which results in the maintenance of the Westerlies and Trades against surface friction, is readily understood in terms of the average structure which theory shows these eddies ought to have (and which they are observed to have); but it cannot be understood in terms of any simple diffusion hypothesis, whether this be based on transfer of angular momentum or on transfer of vorticity.

Transferring his attention to the problem of convection in the earth's core, Dr. Eady pointed out that, due to the varying ellipticity of the geoids and variation in surface temperature, the inner core ought, because of the resulting horizontal density gradients, to rotate more slowly than the mantle. Observed irregular variations in the length of day are consistent with irregular free convective motion in the liquid core. He then outlined a possible natural dynamo mechanism for the maintenance of a variable main magnetic field. Supposing initially a small, approximately dipole (magnetic mode) field to exist, the gradient in rotational velocity previously deduced would wind the lines of force around the earth's axis, leading to a large electric mode field (lines of force roughly parallel to lines of latitude). Convection would draw out the electric mode field into loops. Statistically these loops would tend to set themselves most frequently so that the lines of force had the same direction as the original dipole field where this is strongest, near the inner core. Finally, because of the finite electrical resistance, the lines of force in the sides of the loops near the mantle would diffuse through, ultimately into space, leading to an increase in the strength of the initial dipole which might be sufficient to maintain it against natural decay.

In the discussion, Dr. J. M. Stagg asked how the secular variations could be due to convection in the core since some of the foci of variation are close together. Prof. H. Bondi agreed, pointing out that spherical harmonics of high order decrease rapidly with radial distance. However, Dr. F. J. Lowes said that actual calculation shows that the secular variation is consistent with dipoles in the core of only moderately large strength. Prof. Bondi wondered whether all dynamo theories are invalidated by either Cowling's theorem or a theorem of Batchelor on homogeneous turbulence. Dr. Eady replied that Cowling's theorem does not apply if the field is maintained by turbulent motion; also, the theorem of Batchelor does not apply to the theory he had put forward because homogeneous turbulence has only diffusive properties whereas the mechanism he envisaged was anti-diffusive in one important respect.

E. T. EADY

BUFFALO HUNTING IN ARNHEM LAND

IT is difficult to believe that the docile, domesticated water-buffaloes of the East Indies are the same species as the fierce and dangerous buffaloes hunted in Western Arnhem Land in Australia (*Austral. Mus. Mag.*, **11**, No. 8). Yet the water-buffalo forms an interesting link between Australia, Indonesia and India, and was a profitable experiment in the colonizing of northern Australia in the early nineteenth century. Three buffaloes were imported from Timor into the Melville Island settlement in 1825, and others were introduced over the next twenty years. Once ashore, they became too wild and dangerous to domesticate.

They were well established on Melville Island and on the Cobourg Peninsula on the mainland by 1849. With no natural enemies except the dingo, and as they were remarkably resistant to disease, the animals gradually spread southward into a natural and ideal environment in the vast swamps and grasslands of the Mary, Adelaide and Alligator Rivers and westward to the Darwin coast. Stray bulls have wandered into Victoria Downs, some five hundred

miles to the south, and as far east as Caledon Bay on the Gulf of Carpentaria. The increase was so rapid that by 1885 it was estimated that there were six thousand buffaloes on Melville Island and about sixty thousand on the mainland.

The water or Asiatic buffalo, *Bubalis buffelus*, is a powerful animal, more than five feet high and almost ten feet long. It is heavily built, has short powerful legs with white fetlocks and large hoofs, a short tail and brown hair on an ashy-grey to blackish hide. The immense, hollow and sharply pointed horns may be crescentic in shape or develop into several spirals. The wild herds do not roam far afield from where they were born, their spread through the country in small herds being gradual as their numbers increase. They stay near water, in which they will stand for hours side by side, with only the wide muzzles and horns of their long heads uncovered. The bulls fight for control of a herd of cows in the autumn mating season, and old bulls unable any longer to hold their own with their younger rivals become wandering outcasts of an extremely dangerous nature. A cow bears one calf each year. The bulls will charge a foe threatening the herd.

This buffalo is a native of north-eastern India, where wild ones cause considerable damage to crops. It has a reputation for being the most dangerous animal after the tiger, and is always shot by hunters from an elephant. Hunting began in Australia in 1885, but after 1905 the great and uncontrolled slaughter of the beasts soon depleted the herds perilously and the Government took steps to save them. Permits are now issued for hunters to operate in a defined area. They are allowed to shoot a quota of bulls, but no cows. In recent years between six and eight thousand buffalo skins have been marketed annually for heavy machinery belts and similar uses, at an average price of between £5 and £6 per skin.

The hunting of buffaloes in western Arnhem Land is a dangerous and strenuous job, carried out in the dry season. It demands great horsemanship, skilful shooting and endurance above the ordinary. In the past, the ruthless depletion of the herds, the employment of natives who get little reward but disrupted lives, added to its undesirable nature; these defects have now been rectified. As the dingo is the only natural enemy of the buffalo in Australia, the shooting of a specific number each year is essential or the herds would expand beyond the country's resources to sustain them.

MICROWAVE AMPLIFICATION BY STIMULATED EMISSION OF RADIATION

A NEW instrument called the 'maser' (microwave amplification by stimulated emission of radiation) has been invented by Prof. C. H. Townes, of the Physics Department, Columbia University, for which the claim is made that it enables time to be measured with an accuracy of one part in 10^{11}. The 'clock' used is an ammonia molecule which radiates an electric dipole spectrum as a set of lines of about 6 mm. wave-length and, as used in the instrument, maintains its frequency to the above order of magnitude. This would be sufficient to enable it to measure variation in the rate of rotation of the earth.

According to the details issued by Columbia University, the instrument consists of a molecular beam of ammonia molecules which are excited in an electric field and then pass into a tuned cavity-resonator, where they induce each other to radiate by negative absorption (in effect, giving a form of chain reaction). In this way, all factors causing broadening or displacement of the line emitted are reduced to a minimum. It seems that the method of use is to extract by means of wave-guides the radiation emitted by two 'masers', tuned to different but adjacent frequencies by the ammonia spectrum. When mixed, the beat frequency can then be counted electronically. The 'maser' is also claimed by its inventor to be very effective as an amplifier. The signal is fed into the resonant cavity, and a molecular beam, too weak to cause a complete chain-reaction, is introduced. The signal controls the rate of emission of the radiation, again by negative absorption, and, it is stated, the system is almost completely free from noise. Thus it would be very useful for amplification at millimetre wave-lengths. A limitation, however, would appear to be that the device is scarcely tunable. The only frequencies available are the half-dozen or so lines of the ammonia molecule, all in the 6-mm. region of the spectrum, and the lines of other chemical compounds. It is not stated what sort of a total band may be expected ultimately to be covered by the frequencies of various compounds.

The 'maser' is not the only time-measuring device using microwave spectra of molecules. The alternative method is to use an absorption technique, tuning a conventional oscillator on to exactly the molecular frequency. But Prof. Townes claims that this method is considerably less accurate. As at present built, the 'maser' is a fairly large device, a few cubic feet in volume, but Prof. Townes suggests that this can be considerably reduced. He proposes that, apart from being used as an accurate clock for experimental work on the earth's rotation period, it might also serve as a frequency standard for radio frequencies generally. This would certainly give greater accuracy than the usual quartz crystal, but it is doubtful if this is required, and the method would be less convenient to use, except perhaps in the region of centimetre waves.

MYXOMATOSIS OF RABBITS

THE second report of the Advisory Committee on Myxomatosis* follows fairly soon after the first report (see *Nature*, **173**, 856; 1954) and records that this disease, which appeared in Kent, Sussex, Essex and Suffolk in 1953, had, by the end of 1954, spread to every county in Great Britain except Selkirk. It had appeared as far north as the Orkneys, but its spread was most marked in southern England and in Wales, only isolated outbreaks occurring in northern England and Scotland. A map issued with the report shows the extent of the distribution of the disease at the end of 1954. In Europe the disease exists in France, where it has resulted in the virtual disappearance of rabbits over large areas, and in Belgium, Luxembourg and elsewhere. It also exists in Ireland.

In view of reports that symptoms resembling those of myxomatosis have been reported in animals other

* Ministry of Agriculture and Fisheries—Department of Agriculture for Scotland. Myxomatosis: Second Report of the Advisory Committee on Myxomatosis. Pp. ii+6+1 map. (London: H.M.S.O., 1955.) 1s. net.

than the rabbit (sheep, cats, dogs, hedgehogs, etc.), the Committee says that there is no evidence that the disease can infect man or any animal other than the rabbit. It causes rabbits "much discomfort and distress", but the animals continue to feed until they die, and the Committee is unable to decide whether they suffer pain. They display the symptoms for about a week. The Committee commends the efforts of those who try to kill rabbits affected. The disease is not usually spread by airborne infection, nor by contamination of herbage. It is spread by contact; and, in Great Britain, by the European rabbit flea, which may be disseminated, when it is capable of transmitting the disease, by crows, magpies, buzzards, gulls, foxes and perhaps other predators and scavengers which feed on the diseased rabbits. Mosquitoes, which are the principal vectors in Australia, have not, so far, played much part in spreading the disease in Great Britain, except in some coastal areas. It is possible that, if summer in 1955 is more favourable to mosquitoes, they may play a greater part. Rabbits develop an immunity, but this is not permanent and is not passed on to the offspring; probably less than 1 per cent of rabbits in Great Britain developed immunity in 1954. Nevertheless, the number of immune survivors may increase in the future, and these may be able to re-establish rabbit populations. It is therefore best, the Committee thinks, to kill as many rabbits as possible now, and it commends the organized efforts now in operation to this end and recommends that they should be augmented and given Government help. The Committee expects the disease to spread still more in 1955 and to kill far greater numbers of rabbits then. The critical time for the disease will probably be the winter of 1955–56, when the number of rabbits will probably be the lowest for more than a century. It may then be necessary to intensify the drive against the survivors.

The Committee recommended in its first report that no attempt should be made by man to help the spread of the disease and then decided that it should not be made a criminal offence to spread the disease; it still holds this view, but the Government, in response to opinion in Parliament, accepted an amendment to the Pests Act which made it an offence to use an infected rabbit for spreading the disease.

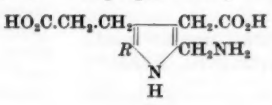
The help given to breeders of domestic rabbits has given good results. The vaccine issued has protected almost 90 per cent of rabbits, and better vaccines are being sought. The importing of rabbits not indigenous to Britain is now prohibited by law. The Food and Drugs Act protects the public against the sale of rabbit meat derived from infected rabbits. Those who are interested in the actual effects of the disease to date will be interested to learn that it has already affected the habits of foxes, which are now turning to rats, fowls and sheep for food, and no doubt the feeding habits of stoats, weasels and other predatory mammals and birds are similarly affected. There has, however, already been a marked improvement in vegetation, especially in grass, so that the loss of some £50 million caused by rabbits is being mitigated. On the other hand, the fur, fur-felt and fur-felt hat trades and the trappers of rabbits must inevitably suffer; and steep chalk downland pastures owe their existence, in some areas, to continuous grazing by rabbits, so that, unless these are now stocked by sheep and cattle, they may become agriculturally valueless.

G. LAPAGE

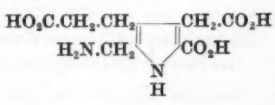
CHEMICAL SYNTHESIS OF PORPHOBILINOGEN

Synthesis of Porphobilinogen and *iso*-Porphobilinogen Carboxylic Acids

PORPHOBILINOGEN, a substance present in the urine of sufferers from acute porphyria, was first isolated by Westall[1] and ascribed the structure (I, $R = H$) by Cookson and Rimington[2]. In the course of an investigation of amino-acids with a pyrrole nucleus, we have synthesized carboxyporphobilinogen (I, $R = CO_2H$) and the isomeric tricarboxylic acid (II), which we propose to designate *iso*-porphobilinogen carboxylic acid.



(I)



(II)

2-Methyl-5-carboxypyrrole-3-acetic acid-4-propionic acid triethyl ester[3] was oxidized to the 2-carbinol with lead tetracetate at 20–25° (melting point, 99°; found: C, 57·5; H, 7·2; N, 3·9. $C_{17}H_{25}O_7N$ requires C, 57·5; H, 7·1; N, 3·9 per cent), and this to the 2-aldehyde, melting point 67°, with the same reagent at 100° (found: C, 57·7; H, 6·8; N, 4·15; $C_{17}H_{23}O_7N$ requires C, 57·8; H, 6·5; N, 4·1 per cent. Dinitrophenyl hydrazone, melting point 179°; found: C, 51·6; H, 5·5; $C_{23}H_{27}O_{10}N_5$ requires C, 51·8; H, 5·1 per cent). The oxime (melting point 58°; found, C, 55·7; H, 6·8; N, 7·5; $C_{17}H_{24}O_7N_2$ requires C, 55·4; H, 6·5; N, 7·6 per cent) on reduction with sodium amalgam gave the 2-amino-ester, melting point 225°; (found: C, 57·7; H, 7·0; N, 7·7; $C_{17}H_{26}O_6N_2$ requires C, 57·6; H, 7·3; N, 7·9 per cent), which, on hydrolysis, gave the acid (I, $R = CO_2H$), isolated through its copper salt. This acid is unstable, rapidly becoming deep purple-pink, and proved extremely difficult to purify and analyse (found: C, 47·9; H, 5·5; N, 10·5; $C_{11}H_{14}O_6N_2$ requires C, 48·9; H, 5·2; N, 10·4 per cent). Since, however, it should yield a substance of the structure suggested for porphobilinogen, we attempted, although only milligram quantities were available, to eliminate the 5-carboxyl group by heating at 105° for 15 min. A mixture resulted which, on treatment with acid, behaved spectroscopically as if it contained porphobilinogen. Prof. C. Rimington has kindly examined this product for us by paper chromatography (see following communication), and shown that it undoubtedly contains traces of porphobilinogen.

This work is being continued with the object of securing enough material for complete chemical identification and biological testing; but as it constitutes a proof of the structure of porphobilinogen by synthesis, it appears to be desirable to record it at the present stage.

Ethyl 4-2′-carbethoxyethyl-3-carbethoxymethyl-5-methylpyrrole-2-carboxylate[4] was oxidized to the 5-carbinol, melting point 102° (found: C, 57·8; H, 6·9; N, 3·9 per cent), and the aldehyde, melting point 69° (found: C, 57·5; H, 6·5; N, 4·0 per cent. Dinitrophenylhydrazone, melting point 140°; found: C, 51·75; H, 5·4 per cent), of which the oxime (melting point 88°; found: C, 55·65; H, 6·85; N, 7·7 per cent) on reduction gave the triethyl ester of

(II), melting point 185° (found: C, 57·8; H, 7·4; N, 8·3 per cent), from which the free acid was obtained by hydrolysis (found: C, 48·4; H, 5·9; N, 10·4 per cent). This acid is not decarboxylated when heated at 105° for 15 min.

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March 9.

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Decarboxylation of Porphobilinogen- and *iso*-Porphobilinogen-α-Carboxylic Acids

Pyrrole derivatives such as the tricarboxylic acids (I) and (II) synthesized by Prasad and Raper (see preceding communication) give no immediate colour with Ehrlich's reagent (*p*-dimethylaminobenzaldehyde in *c.* 5 *N* hydrochloric acid), but do so very slowly at room temperature or rapidly on heating as the α-COOH group is displaced by the coupling reagent. Porphobilinogen, with H in place of COOH in (I), reacts at once at room temperature.

Prasad and Raper attempted the partial decarboxylation of (I) and (II), in order to form porphobilinogen and an isomeric *iso*-porphobilinogen, respectively, by heating at 105° for 15 min., and we examined their reaction products by paper chromatography, using butanol/acetic acid/water as solvent and Ehrlich's reagent as spray[1]. There appeared to have been no decarboxylation of (II) and, in the case of (I), only a trace of promptly reacting material was present in the position expected for porphobilinogen. Some general decomposition had taken place, resulting in a residue of brown immobile material at the point of application. On heating the sprayed paper at 100° for about 1 min., strong red spots appeared due to unchanged (I) and (II), the R_F's being less than that of porphobilinogen. Owing to the small amount available of the acids (I) and (II), we have carried out most of our further work on the materials which had been subjected to the unsuccessful attempt at decarboxylation by heating; the symbols (I) and (II) are retained.

In one experiment, lactam formation was attempted by applying the conditions used by Cookson and Rimington[2], namely, reaction in aqueous pyridine with acetic anhydride at 0°. Paper chromatography of (I) so treated showed not only a spot developing after heating in the same position as the untreated material, but also promptly appearing spots in the same positions as porphobilinogen lactam and acetyl-porphobilinogen markers, but superimposed on much general streaking. The possibility of decarboxylation in aqueous pyridine was therefore investigated, and it has been found that smooth and practically quantitative decarboxylation of (I) in the α-position can be achieved by heating in 50 per cent aqueous pyridine in the presence of a trace of copper acetate for about 2·5 min. (boiling water-bath).

A chromatogram of the reaction mixture (Fig. 1) shows the appearance of porphobilinogen and the virtual disappearance of (I). Moreover, after adding acetic anhydride to the reaction mixture, as for lactam formation, and chromatographing, the porphobilinogen spot disappears and spots appear in the same positions as porphobilinogen lactam (strong) and acetyl-porphobilinogen (very weak) markers respectively. A third, unidentified, weak spot lies between porphobilinogen and its lactam.

The behaviour of the synthetic products derived from (I) is thus chromatographically identical with that of the natural material, its lactam and acetyl derivative.

Heating (II) for 2·5 min. in 50 per cent aqueous pyridine containing a trace of copper acetate leads to complete α-decarboxylation, the resulting *iso*-porphobilinogen giving a prompt red colour with Ehrlich's reagent at room temperature and having an R_F the same as that of porphobilinogen itself. Further treatment of the reaction mixture with acetic anhydride, as for lactamization of porphobilinogen, affords an Ehrlich-positive product which when chromatographed reveals two components. These give prompt colour with the reagent at room temperature but fade considerably more rapidly than do the spots of porphobilinogen lactam and acetyl-porphobilinogen; moreover, their positions are different, the less mobile one lying between porphobilinogen and its lactam, the other lying very slightly in advance of the lactam. A further difference was noted under ultra-violet light; porphobilinogen lactam shows an intense blue fluorescence whereas the more mobile spot, derived from α-decarboxylated (II), shows the merest trace, if any, of fluorescence. The identity of these products remains to be determined, but it is possible that one of them is the N-acetyl derivative of *iso*-porphobilinogen.

After treatment of the tricarboxylic acid (II) as for lactamization, no Ehrlich-reacting material could be detected chromatographically with the usual amount of material either with or without heating of

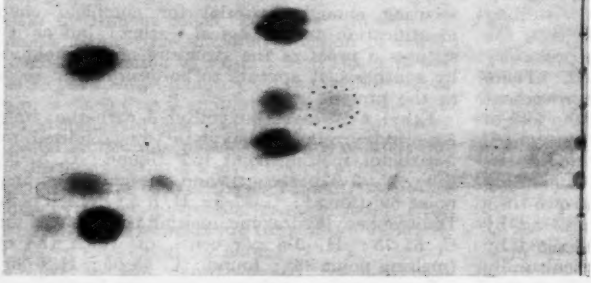
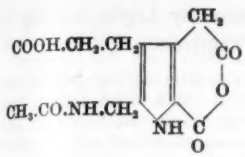
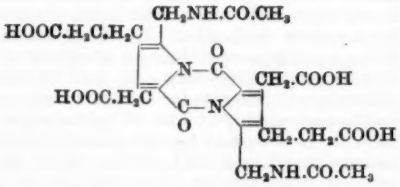

Porphobilinogen
Porphobilinogen lactam
Substance I; the spot ringed by dots develops strongly on heating
Substance I + aq. pyridine + copper acetate heated 2·5 min. in water bath
As above, then lactamized by addition of acetic anhydride at 0° C.
Porphobilinogen + aq. pyridine + acetic anhydride at 0° C. Porphobilinogen lactam (strong) and acetyl-porphobilinogen (weak)

Fig. 1



(III)



(IV)

the sprayed paper. From an examination of the structure of (II), the possibility emerges that the cyclic anhydride (III) may have been formed which, having no free α-position, nor any easily displaceable group in that situation, would not be expected to develop colour with the Ehrlich reagent. Alternatively, the formation of the pyrocoll (IV) (presumably N-acetylated) might be considered, although with known pyrrole α-carboxylic acids this reaction has been reported only after heating with acetic anhydride[2].

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CONDITIONS OF EXPLOSION OF AZIDES

Effect of Size on Detonation Velocity

INITIATION and growth of explosion. Some recent experiments[1] have shown that if azide crystals of different sizes are heated at a fixed temperature, crystals greater than a critical thickness will explode, whereas those below a critical thickness will decompose slowly. The critical thickness decreases with increasing temperature, and for a temperature of *c.* 400° C. it is a few microns. Additional experiments[1], in which azides were irradiated with electrons, neutrons and fission products, show that the activation of a small group of adjacent molecules is not sufficient to cause explosion. These observations support the view put forward earlier[2] that the necessary size of hot spot is large on a molecular scale (10^{-5}–10^{-3} cm. in diameter). Courtney-Pratt and Rogers describe below the initiation of explosion in azides by very intense ultra-violet light. These results may also be explained on a thermal mechanism involving the formation of a 'hot layer' of thickness *c.* 10^{-4} cm. which is in the same range.

Detonation velocity in high explosives. In all this previous work we have been concerned with the influence of size on the first stage of the explosion—the initiation and growth. We have now extended the experiments and studied the influence of physical dimensions on the last stage of the explosion, that is, on the stable detonation. The effect of charge diameter on the detonation velocity has been studied by a number of workers (for example, Bichel, Mettegang, Dautriche, Kast, Hiscock, E. Jones, Paterson and Ford) and the results have been summarized by J. Taylor[3] and by Eyring *et al.*[4]. The experiments have been almost exclusively concerned with high explosives such as TNT and complex mixtures containing nitroglycerine: in all cases the charge diameters were large (of the order of 1–20 cm.) compared with the lengths of the reaction zones. The estimated length of the reaction zone of finely powdered TNT is, for example, about 0·3 cm. and that of liquid nitroglycerine is 0·04 cm. The detonation velocity increased with the diameter of the explosive charge, approaching a maximum asymptotically, and the results may be explained in terms of the hydrodynamic theory.

Detonation velocity of azides. Little work has been done with the initiating explosives, and the experiments described here deal with the effect of thickness of charge on the detonation velocity of lead azide when pressed into very thin sheets or slabs. The thickness of these was comparable with the anticipated length of the reaction zone and varied from about 20 to 500 microns. The sheets were 1·3 cm. long and 0·5 cm. wide, and were made in a device which ensured that the density did not vary by more than a few per cent from one sheet to another. The mean density of the sheets was 3·14 gm. cm.$^{-3}$, compared with the crystal density of about 4·60 gm. cm.$^{-3}$. 'Pure' lead azide from a single batch was used throughout. The detonation velocity was determined by means of a simple drum-camera. A sheet of known thickness was placed at the end of a trail (about 2 cm. long) of powdered lead azide on a glass plate over a slit, and the explosion initiated by means of an electrically heated wire in the powder. The results are plotted in Fig. 1. It will be seen that for sheets of thickness of 400 microns and greater, the detonation velocity is constant at *c.* 5·5 km./sec. For charge thicknesses less than this, the detonation velocity decreases steadily and falls to *c.* 2 km./sec. when the thickness is *c.* 20 microns.

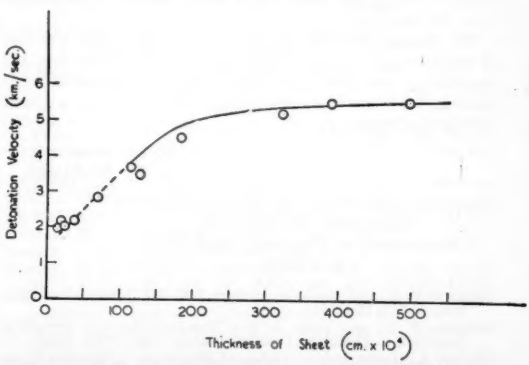

Fig. 1. Relation between detonation velocity and thickness for compressed sheets of lead azide. The experimental points lie on the continuous curve which has been calculated from the hydrodynamic theory

An attempt has been made to explain these results in terms of the expanding jet theory of H. Jones[5] (itself an extension of the hydrodynamic theory) modified to apply to the present experimental conditions. The theory is based upon the fact that in condensed explosives a lateral expansion of the decomposing materials will always take place. If this expansion within the reaction zone takes place before the reaction is complete, part of the decomposition occurs at a lower effective loading density, and the detonation velocity will therefore be lower than if no lateral expansion took place. Jones's calculations were made for cylindrical charges where the constraint is symmetrical about the axis of the charge. In our experiments, with very thin sheets of explosive, this was not so, since the width of the charge is much greater than the thickness. We have assumed that the expansion is symmetrical in a vertical direction about the axis of the charge, and that no lateral expansion takes place horizontally. We should then expect the detonation velocity to decrease more gradually with decreasing thickness than it would with a cylindrical charge in which expansion in two dimensions will take place. The reaction is initiated at the shock-wave front and develops over a certain distance, X, the reaction zone. The theory provides an expression for the detonation velocity V, for any thickness of charge in terms of the maximum stable velocity V_0 and the ratio of the length of the reaction zone (X) to the thickness of the charge. From the thickness for which $V = V_0$ we can calculate X. From Fig. 1 it is seen that for lead azide the critical thickness lies between 400 and 600 microns. This gives a value for X of approximately 75 microns. The theoretical relationship between the detonation velocity and the thickness of the charge is plotted as a continuous curve. It will be seen that there is fairly good agreement between experiment and theory over the range of thicknesses for which the theory is valid, that is, for thicknesses greater than the length of the reaction zone. For charge thicknesses less than 100 microns the curve (dotted) joining the experimental points is a smooth continuation of the theoretical curve.

We may conclude, therefore, that the variation of detonation velocity with thickness of charge for azides is analogous, though on a very different scale, to that observed for high explosives and can be explained reasonably well in terms of the hydrodynamic theory. The calculated length of the reaction zone for lead azide from these experiments is *c.* 75 microns.

We thank Prof. H. Jones, of the Imperial College of Science and Technology, for help in modifying his expanding jet theory to suit our experimental conditions, and the Ministry of Supply (Air) for a grant to the Laboratory.

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Initiation of Explosion by Light and by Flying Fragments

Initiation by light. Crystalline azides decompose slowly when irradiated with ultra-violet light[1], but explosion does not normally occur. If, however, the light intensity is very great, a variety of sensitive substances may be exploded[2].

A study of the photo-initiation of explosion in silver azide by high-intensity light flashes has been made. Small crystals of silver azide were irradiated in vacuum with ultra-violet light from a krypton-filled quartz flash-tube. The total amount of light falling on a square millimetre of crystal in the wave-length range 2000–3600 A. was measured by a photoelectric photometer calibrated against a chemical actinometer. (Light of wave-length less than 2000 A. is absorbed by the quartz envelope of the flash-tube, while wave-lengths greater than 3600 A. are not absorbed by the azide crystal or by the actinometer.) The time for the flash intensity to rise to its peak and fall to one-tenth peak was constant at 61 ± 2 μsec.

Absorption measurements show that crystals 10^{-2}–10^{-3} cm. thick used for these experiments transmit considerably less than 0·5 per cent of light at all wave-lengths less than 3500 A. With the crystals available it was not possible accurately to measure the absorption coefficient at these wave-lengths, but at 3500 A. it is of the order 10^3 cm.$^{-1}$ and rises very steeply as the wave-length decreases.

It has been found that a critical amount of light is required to initiate the explosion of a crystal of silver azide. This critical light absorption corresponds to a total energy input of 8×10^{-4} cal. into each millimetre squared of the crystal. To calculate this energy the spectral distribution of the light output has been assumed to be the same as that reported by Christie and Porter[3] for a lamp operating under similar conditions. The critical amount of light is independent of the mass of the crystal irradiated over the range 0·2–1·5 mgm. and of the projected area of the crystal facing the lamp. If the crystals are irradiated with an ultra-violet lamp of normal intensity, they darken considerably, due to the formation of silver by their partial decomposition. With such crystals, although absorbing light at wave-lengths greater than 3600 A., the critical amount of light, as measured by the photometer, required to initiate explosion is not appreciably affected.

The absorption of light of these wave-lengths by a crystal causes electrons to be raised to various states of excitation. Our knowledge of the behaviour in a crystal of electrons so excited indicates that their energy will be degraded very rapidly to heat, that is, excitation of vibrational and rotational degrees of freedom. A hot layer will be formed on the surface of the crystal. With a knowledge of the variation of intensity of the flash with time, the thermal conductivity, and the absorption coefficient of the azide, the size of the hot layer and the temperature distribution within it may be calculated. At present we do not have all this information. The absorption coefficient for an ionic crystal in its fundamental ultra-violet absorption band is often of the order 10^5 cm.$^{-1}$. At some wave-lengths less than 3500 A. the absorption coefficient of silver azide will probably reach this figure. Hence 99 per cent of all the incident radiation between 2000 and 3600 A. which enters the azide crystal will be absorbed in a layer the thickness

of which may vary between 4×10^{-3} and 4×10^{-5} cm., depending on wave-length.

Because of the uncertainty in the absorption coefficient, no detailed calculation of the thickness and temperature of the hot layer formed is possible. The specific heat[4] and density[5] of silver azide are 0·12 cal./gm. and 4·8 gm./cm.^{3}, respectively. Therefore, 8×10^{-4} cal./mm.^{2} would raise the temperature of a surface layer 3×10^{-4} cm. thick about 500 deg. C., assuming that the layer were heated uniformly throughout its thickness. Bowden *et al.*[6] have shown experimentally, and Rideal and Robertson[7] theoretically, that a hot spot with dimensions of the same order as the thickness of this layer and at a temperature of 500° C. will initiate explosion. These experiments strengthen the view that the initiation of explosion requires the formation of a hot spot which is large on a molecular scale. Further, the independence of the critical amount of light on the projected area of the crystal facing the flash-tube suggests that the smallest dimension and temperature of the hot spot are the critical parameters deciding successful initiation. The mechanism for initiation of explosion of silver azide by light appears to be essentially a thermal one. Further experiments have now been devised whereby the moment of explosion can be related to the intensity–time curve for the light-flash. The first results obtained suggest that factors other than the total energy absorbed are also important in the initiation process.

Light emission and the propagation of explosion. Absorption of light of wave-length less than 3600 A. will cause the explosive decomposition of silver azide if the intensity is sufficiently high. Audubert *et al.*[8] studied the light emitted when solid lead, silver, potassium and sodium azides decomposed slowly, and found that light of wave-lengths between 2000 and 2800 A. was emitted. The spectral distribution of this light was independent of the cation, but the intensity was proportional to the rate of decomposition of the azide. If the intensity continued to increase with increasing rate of decomposition, the explosive reaction would be accompanied by high-intensity light emission. If this were so, light might play a significant part in the propagation of explosion from one sample of azide to another. An experiment has been made to test this possibility. Most of the experiments were carried out in vacuum, so that any light emitted at wave-lengths less than 2000 A. would be utilized.

The experiment consisted of firing a sample of azide located at one focus of a front-aluminized elliptical mirror with another sample of azide located at the conjugate focus. Experiments carried out in air showed that the shock wave produced by the explosion of the first sample and focused by the mirror on the second never caused the explosion of the latter. When the experiment was carried out in vacuum with lead azide at the first focus and silver azide at the second, the silver azide exploded. Amounts of lead azide greater than a critical amount had to be fired at the first focus. Similar results were obtained using silver azide at both foci. Further experiments showed that a considerable amount of material reached the second sample of azide, although there was no direct path between the two samples. The explosion of the azide at the first focus deposited a considerable amount of lead on the mirror surface, but the optical condition of the mirror surface did not affect the result. If a fluorite window, which transmits light down to 1800 A., was placed over the azide at the second focus, explosion was never transmitted but the window was covered with material particles.

Flying particles and the propagation of explosion. These results show that in these experiments the transmission of detonation was by particles thrown off from the explosion of the azide at the first focus. The break-up of azide crystals and the production of flying particles as a result of thermal decomposition has been observed by Bowden and Singh[9]. There was no evidence here that ultra-violet light plays any significant part in the transmission of explosion. The nature of the particles which reached the second sample was investigated by placing a microscope cover-slip at the second focus. Microscopical examination showed that, in addition to very small particles, some large particles of the order of *c.* 10^{-4} cm. diameter had reached the second focus.

Particles could reach the target azide only after reflexion at the mirror surface. Hot lead particles would lose most of their kinetic energy and be cooled considerably in such a reflexion. It is unlikely that, if the larger particles were metallic lead, they would arrive at the target with sufficient energy to create a hot spot of the size required to initiate explosion. It is suggested that the larger particles arrive at the target as small fragments of undecomposed lead azide. Energy is then available to the target from their kinetic energy and from the exothermic decomposition of the particle. Further, this energy will be concentrated on an area *c.* 10^{-4} cm. diameter. The decomposition of such a particle could easily produce a hot spot of the size and temperature which has been found necessary to initiate the explosion of silver and other azides.

Summarizing these results, we see that the explosion of silver azide may be initiated by light provided the intensity exceeds a critical value. The mechanism is probably a thermal one, and in this respect is similar to that discussed by Bowden and McLaren in that it requires a hot layer the thickness of which is large on a molecular scale. The light emitted by the exploding azide itself does not, under the conditions of these experiments, initiate the explosion of another sample, but tiny fragments flying from the crystal readily transmit the explosion.

We thank the Ministry of Supply (Air) for a grant for apparatus and the Ramsay Memorial Fellowships Trust for a fellowship to one of us (G. T. R.).

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LETTERS TO THE EDITORS

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Anthocyanins of the Leaf of the Copper Beech (*Fagus sylvatica*) and the Fruit of the Cultivated Strawberry (*Fragaria virginiana*)

The pigment of the copper beech was identified in 1932[1] as cyanidin 3-galactoside; two years later, the colouring matter of wild strawberries was stated to be pelargonidin 3-galactoside[2].

In the former case a small specimen of the anthocyanin was isolated in substance; but in the latter case, the conclusion was reached from the results of reactions in solution. In these tests the distinction between isomeric glycosides was made only by observation of distribution between partly miscible solvents, and this is a property known to be affected by the presence of other substances. It therefore seemed desirable to examine the chromatographic behaviour of these anthocyanins. Using synthetic specimens[3] and the method of Bate-Smith and Westall[4] (paper chromatograms; *n*-butanol – acetic acid – water, 4 : 1 : 5, as solvent; original solution in 1 per cent hydrochloric acid, 0·1 per cent with respect to anthocyanin), it was found that chrysanthemin (cyanidin 3-glucoside) and idaein (cyanidin 3-galactoside), though very similar in behaviour, could be definitely distinguished, or even separated, in a run of 24–30 hr. The R_F's are 0·395 and 0·38 for the glucoside and galactoside respectively, but careful standardization of the conditions ensured unambiguous results. A mixture gave an elongated band, and there was no evidence of any holding back of the faster-moving glucoside by the galactoside.

The copper beech pigment (25 mgm.) was isolated as already described from leaves (1 kgm.) collected in June 1954 from a tree near the laboratory, except that the purification through the picrate was omitted. On chromatography the pigment ran like idaein and similarly, as a compact spot, when mixed with idaein. When mixed with chrysanthemin, the elongation of the coloured region was the same as that obtained with a mixture of synthetic idaein and chrysanthemin. The identification of this anthocyanin as idaein was therefore confirmed.

Sondheimer and Kertesz[5] purified the anthocyanin of a variety of strawberry grown in the United States and found it to be callistephin, since cyanidin and glucose (as D-glucosazone) were obtained on hydrolysis. Although the wild strawberry (*Fragaria vesca*) was not available in sufficient quantity, we thought it of interest to examine garden strawberries (from Norfolk) with the aid of the chromatographic procedure.

Preliminary experiments showed that the divergence between pelargonidin glucoside (callistephin) and pelargonidin galactoside (called fragarin, possibly erroneously) was greater than that between the corresponding cyanidin derivatives. The R_F of the glucoside was about 0·45 and that of the galactoside, 0·38. The pigment (*c.* 35 mgm.) from the cultivated strawberries (1·5 kgm.) was isolated by means of a method closely similar to that used for the beech leaves. Its chromatographic behaviour was the same as that of synthetic callistephin and differed from that of synthetic pelargonidin 3-galactoside.

The possibility remains that the anthocyanin of wild strawberries may differ from that of the cultivated kinds; a precedent is the occurrence of cyanidin galactoside in European cranberries[6], whereas those obtained from Newfoundland were found to be coloured by peonidin glucoside[7].

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Release of Aromatic Compounds from Birch and Spruce Sawdusts during Decomposition by White-rot Fungi

During investigations into the decomposition of lignin by soil micro-fungi, it was found that a large number of these were able to decompose several aromatic compounds which are believed to be related to lignin[1]. In an attempt to discover whether such compounds are released on biological decomposition of lignin, two wood-rotting fungi, *Polystictus versicolor* and *Trametes pini*, both white-rots, were grown on birch and spruce sawdusts. 25 gm. of sawdust (previously extracted with alcohol-benzene) was added to each flask and moistened with 40 ml. of a mineral salts medium (0·1 gm. potassium dihydrogen phosphate, 0·05 gm. potassium chloride, 0·05 gm. magnesium sulphate, 0·5 gm. peptone, 1 gm. glucose, 100 ml. water). The flasks were sterilized by steaming for one hour on three successive days. The fungi produced much growth which penetrated the sawdust, causing it to become lighter in colour. After six months incubation at 22° C., 9 gm. of this material was extracted with 2 per cent sodium hydroxide. On acidification of the extract a considerable precipitate was formed which was centrifuged off; the supernatant was then extracted with ether. The ether was evaporated off and the residue dissolved in a small volume of absolute alcohol for application to chromatography papers. These were developed with a single-phase mixture consisting of *n*-propanol – ammonia (sp. gr. 0·880) – water (80 : 5 : 15), run for two periods of 24 hr. at 21° C. and dried between successive runs. Two sprays were used: (*a*) diazotized sulphanilic acid[2] for phenolic groups, and (*b*) 2 : 4-dinitrophenylhydrazine[3] for aldehydes.

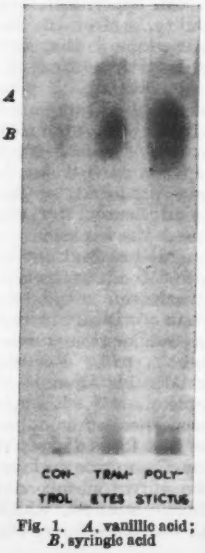

Fig. 1. *A*, vanillic acid; *B*, syringic acid

Fig. 1 shows the result when birch extracts were sprayed with diazotized sulphanilic acid. With this spray, vanillic acid gives an orange spot and syringic acid a red spot. Both extracts showed strong spots of each of these acids, whereas the control (which had not been inoculated) gave only very faint spots. Vanillic acid alone was released from spruce sawdust by both fungi. Using 2 : 4-dinitrophenylhydrazine, both fungi gave faint spots of vanillin and syringaldehyde from birch sawdust and of vanillin from spruce sawdust; but similar spots were given by the controls.

These results are of interest as they conform with chemical analyses of lignin[4], which show the occurrence of guaiacyl and syringyl groups in hardwood lignin and of guaiacyl groups alone in softwood lignin.

These compounds are released probably by the action of extracellular enzymes produced by the wood-rotting fungi. It is possible that such molecules can thus be rendered available to micro-fungi under natural conditions, as it has been shown that such fungi do not themselves release these substances from sawdust.

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Synthesis of Oligosaccharides by Growing Cultures of *Betacoccus arabinosaceous*

Koepsell *et al.*[1] have shown recently that oligosaccharides are formed when the dextransucrase of *Leuconostoc mesenteroides* (*NRRL B-512*) acts on sucrose in the presence of certain simple sugars, which serve as chain-initiators. We have observed a similar phenomenon with the dextransucrase and with growing cultures of *Betacoccus arabinosaceous* (Birmingham strain). When grown on a medium containing sucrose (10 per cent), yeast extract and inorganic salts, this organism produces a dextran in which the principal glucosidic linkages are α-1 : 6 and the branch points involve positions 1 and 3[2]. Fructose, traces of glucose and a ketose-containing disaccharide can be detected in the medium. The degree of branching in the polysaccharide is dependent, *inter alia*, on the magnesium content of the medium; dextran samples produced from magnesium-rich and magnesium-deficient media have been proved to have average chain-lengths of 6–7 and 40–50 anhydroglucose units, respectively[3].

It has now been shown that very profound reductions in the molecular size of the dextran produced by the growing organism can be effected by the addition of suitable simple sugars to the culture medium; in extreme cases, di-, tri- and tetrasaccharides are the principal products. This work was a logical development of studies in which glucose, maltose, *iso*maltose and other sugars were found to serve as chain-initiators in transglucosylations by the enzyme *Betacoccus arabinosaceous* dextransucrase (cf. Koepsell *et al.*[1]).

The addition of glucose (40 per cent w/v) to the standard culture medium almost completely inhibited growth of the organism, whereas with 10 per cent glucose there was good growth, accompanied by the formation of polymeric material. However, with 20 per cent glucose dextran production was noticeably depressed and *iso*maltose, *iso*maltotriose and their higher homologues were prominent on paper chromatograms of the culture solution.

The addition of 10–50 per cent maltose (w/v) to the standard medium (40 c.c., to which another 4 gm. of sucrose was afterwards added) had a similar effect; at the latter concentration the amount of product which was insoluble in 66 per cent ethanol was negligible. Paper chromatographic analysis of the solution revealed the presence of a large amount of panose, together with unchanged maltose, higher aldosaccharides, fructose, a ketose-containing disaccharide and a ketose-containing trisaccharide. Fractionation of the mixture on a charcoal column[4] gave a trisaccharide fraction (3·5 gm.) and a mixed oligosaccharide fraction (4·5 gm., eluted by 15–20 per cent ethanol); crystallization of the former from aqueous methanol afforded panose, melting point and mixed melting point 222–224° (decomp.) $[\alpha]_D^{21}$ + 153·9° (equil.; in water).

Chromatographic evidence was also obtained of: (*a*) non-reducing products (presumably methyl glycosides) in the oligosaccharide range when methyl α-D-glucopyranoside (25 per cent) was added to the standard medium; (*b*) an unidentified trisaccharide on the addition of cellobiose (30 per cent); (*c*) a ketose-containing disaccharide on the addition of fructose (25 per cent); and (*d*) probable tri- and tetra-saccharides when lactose (10 per cent) was incorporated in a modified medium containing only 2 per cent sucrose.

These results with growing cultures, like those obtained with dextransucrase itself, point to a multi-chain mechanism of synthesis and throw light on the structural requirements for chain-initiation. In addition, they provide a convenient route for the preparation of appreciable quantities of higher saccharides (and their glycosides) with a predetermined range of molecular weight, which might well prove to be useful commercially for the production of gums, anti-staling agents for bread, plasticizers, etc. We have shown also that they simplify the difficult preparation of dextran-free dextransucrase by providing a source in which the enzyme is accompanied by only traces of the polysaccharide.

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Utilization of Metaphosphate for Phosphorylation by Cell-free Extracts of *Mycobacterium smegmatis*

In a recent communication in *Nature*[1], we pointed out that it has been suggested by several authors that metaphosphate may be a source of 'high-energy' phosphate in the cells of a number of lower organisms, but that this had not been proved[2]. The question has since been investigated in this laboratory.

Table 1. Utilization of Labile Phosphate by Cell-free Extracts of *M. smegmatis*

Mixtures incubated	7-min. labile phosphate			Stable phosphate			Orthophosphate		
	Start	Finish	Change	Start	Finish	Change	Start	Finish	Change
(1) Extract + glycerol + metaphosphate	101·6	87·8	−13·8	64·1	66·8	+2·7	59·5	70·8	+11·3
(2) Extract + glycerol + adenosine triphosphate	112·2	15·8	−96·4	115·6	193·1	+77·5	66·8	86·6	+19·8
(3) Extract + glycerol + adenosine triphosphate + metaphosphate	195·6	59·8	−135·8	123·0	230·4	+107·4	69·1	99·4	+30·3

All figures represent μgm. phosphorus per ml. of mixture

The experimental method was based on that used by Hunter[3] in showing the phosphorylation of glycerol by cell-free extracts of mycobacteria. Four-day old surface growth of *M. smegmatis* was harvested, washed, and about 5 gm. (wet-weight) ground by hand with about 10 gm. acid-washed Merck alumina. It was then made into a slurry with 25 ml. of *M*/10 phosphate buffer, *p*H 7·40, and ground in a ball-mill for 10 min. Whole cells and alumina were removed by centrifuging three times at 2,700 *g*, each time for 10 min. All these operations were performed at as low a temperature as possible. The *p*H was re-adjusted to 7·40. The extract was dialysed against three changes of tap water at about 4° C. After dialysis the *p*H was readjusted to 7·40.

The other solutions used in the experiment were: (i) 2 per cent glycerol; (ii) 1·5 per cent solution of the barium salt of adenosine triphosphate (Schwartz Laboratories) dissolved in *N*/20 hydrochloric acid, the barium precipitated by adding potassium sulphate, the solution brought to *p*H 7·40, and centrifuged; (iii) 2 per cent sodium metaphosphate (Hopkin and Williams) was suspended in 1 per cent potassium sulphate, the *p*H adjusted to 7·40, the suspension kept overnight, its *p*H readjusted, the suspension centrifuged, and the supernatant diluted 1 : 1 with water.

5 ml. of the cell-free extract and 1 ml. each of the required solutions were pipetted into 25-ml. conical flasks; water was added where necessary to give a final volume of 9 ml., and the flasks then thoroughly evacuated and incubated at 37° C. for 4 hr. Two samples, taken at both the beginning and end of this period, were pipetted into an equal volume of ice-cold 10 per cent trichloracetic acid and stirred. One sample was centrifuged and orthophosphate determined on the supernatant. The other was heated at 90° C. for 15 min. to extract the phosphorus compounds, centrifuged, and the total phosphorus and 7-min. labile phosphate in the supernatant determined. The results of one such experiment are shown in Table 1.

Under the conditions of these experiments, therefore, metaphosphate was hydrolysed to a slight extent to orthophosphate by the dialysed extract. In the absence of adenosine triphosphate, no further change took place. When adenosine triphosphate was added as the sole 'high-energy' phosphate source, more than 50 per cent of its labile phosphate was converted to glycerophosphoric acid. On the addition of metaphosphate in addition to adenosine triphosphate, a considerably greater conversion of labile phosphate to glycerophosphoric was found. These results show that the cell-free extract was capable of utilizing metaphosphate for the phosphorylation of glycerol in the presence of adenosine triphosphate, presumably by phosphorylation of adenosine diphosphate to adenosine triphosphate. As the experiments were done under anaerobic conditions, metaphosphate must have provided the energy for the phosphorylation.

As would be expected, adenosine diphosphate was capable of replacing adenosine triphosphate in the system, but adenosine monophosphate was not.

The enzyme system is being further investigated and detailed findings will be published elsewhere.

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Tumour-initiating Action of Urethane and its Inhibition by Purine Precursors

Urethane injected, given by mouth, or applied to the skin, induces the formation of multiple lung adenomata in mice and rats. It also inhibits the growth of some transplanted animal tumours, and induces remissions in human leukæmia. Its many other biological effects include the induction of chromosome abnormalities and mutations.

It was shown recently[1] that urethane has the power of initiating the carcinogenic change in mouse skin without being itself carcinogenic for this tissue, or producing any other detectable change in it. This was demonstrated by a technique based on that used by Berenblum and Shubik[2] and by others for the investigation of the stages of chemical carcinogenesis. Urethane was applied to the skin of the back and followed, after an interval, by weekly applications of croton oil. Many papillomata and some carcinomata developed. No skin tumours appeared on mice treated repeatedly with urethane alone, and only a very few on control mice treated with croton oil alone.

Little is known of the chemical processes underlying the various biological effects of urethane. Todd (quoted by Haddow and Sexton[3]) suggested that urethane may interfere with nucleotide synthesis.

Table 1

Group (20–30 mice per group)	Additions to drinking water	Applications to skin		Results
	1st to 11th days (inclusive)	On 4th and 7th days	22nd day onwards	Average number of papillomata per surviving mouse at the end of treatment
1	Sodium formate	(*a*) ethyl formate, (*b*) urethane, (*c*) ethyl formate — at intervals of 30 min.	18 weekly applications of croton oil	2·8
2	Glycine	(*a*) glycine ethyl ester, (*b*) urethane, (*c*) glycine ethyl ester — at intervals of 30 min.	18 weekly applications of croton oil	2·5
3	Sodium formate and glycine	(*a*) glycine ethyl ester, (*b*) ethyl formate, (*c*) urethane, (*d*) glycine ethyl ester, (*e*) ethyl formate — at intervals of 30 min.	18 weekly applications of croton oil	0·3
4	Nil	Urethane only	18 weekly applications of croton oil	2·3
5	Nil	Nil	18 weekly applications of croton oil	0·2

Boyland[4] points out that urethane may prevent the methylation of uracil to thymine, and so lead to a deficiency of this purine. In support of this hypothesis he quotes McKinney, who showed that urethane can inhibit the transmethylation of nicotinamide by methionine in tissue homogenates. However, McKinney also claimed that a similar effect was produced by certain homologous carbamates, which are known to show little or no antileukæmic activity, lung tumour-inducing activity, or ability to initiate skin-tumour formation.

Boyland[4] also refers to work by himself and Koller showing that the chromosome-damaging action of urethane can be partially neutralized by simultaneous administration of thymine, an essential constituent of deoxyribonucleic acid.

The suggestion that urethane may act in leukæmia by interference with purine synthesis was put forward by Haddow and Sexton[3], in view of the aberration of purine metabolism in this disease.

The hypothesis which underlies the experiment, of which a preliminary report is given below, is that urethane competes with one or more of the precursors in purine synthesis, and, in doing so, perhaps takes part in the formation of an unphysiological purine-like substance. Such a substance might be responsible for some of the biological actions which have hitherto been attributed to urethane itself; for example, its antileukæmic and tumour-inhibitory effects, acting similarly to the synthetic purine antagonists such as 2,6-diaminopurine or 8-azaguanine.

It was thought that if suitable purine precursors were supplied in high concentration at the time that urethane was being administered, the tumour-initiating action of the latter for mouse skin might be inhibited. Glycine and formate were chosen for this purpose, as it was known from the work of Buchanan *et al.*[5] that formate and glycine both supply components for the synthesis of the uric acid skeleton. Moreover, Totter *et al.*[6] had shown that the same substances serve as precursors for the nucleic acid purines.

Since absorption of urethane through the skin is very rapid, and since 90 per cent of injected urethane is broken down (to ethyl alcohol, ammonia, carbon dioxide and water) within 24 hr.[7], there is little doubt that the method of administration of glycine and formate adopted (see Table 1) maintained an excess of these substances throughout the period of effective presence of urethane in the body.

Five groups, each of twenty to thirty male mice of a stock albino strain, were treated as shown in Table 1.

The last column of Table 1 shows that the result of this experiment was quite definite. Large numbers of tumours appeared in group 4, and very few in group 5, as was expected from past experience. Tumour incidence in groups 1 and 2 was not significantly different from that in group 4. In group 3, however, very few tumours appeared, the incidence being not significantly higher than that in group 5.

Thus it was shown that formate and glycine administered together, in the manner described, inhibit the initiation by urethane of skin-tumour formation in the mouse, but that neither has any effect on it when administered alone.

The experiment is being repeated and extended.

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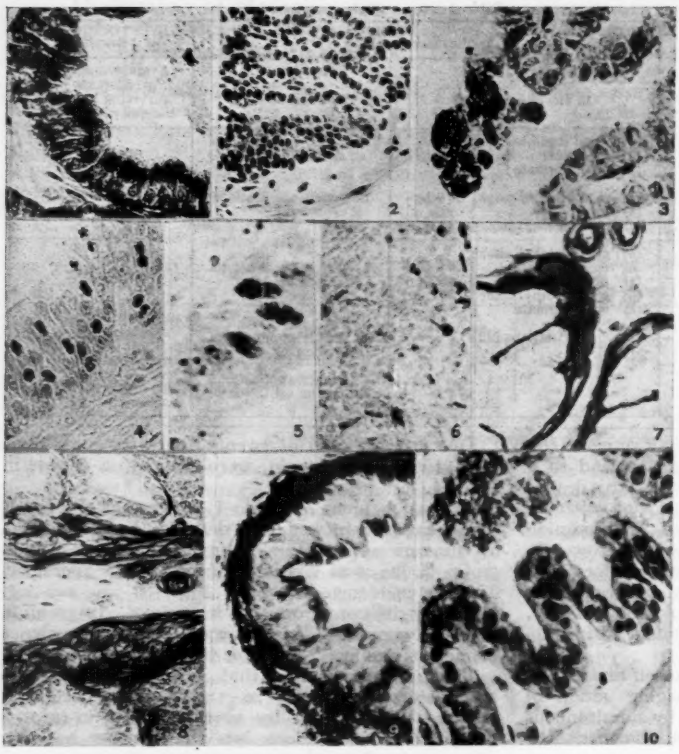
Histochemical Control in Biochemical Estimation of Prostatic Phosphatase Activity

Biochemical estimation of acid or alkaline phosphatase activity of the prostate sometimes indicates no change under experimental conditions, or in some cases an increase or decrease. Histochemical examination of the gland under such conditions can show fundamental alterations in distribution of phosphatase activity that are not reflected



(1) Localization of acid phosphatase activity in Golgi region of the epithelial cells in normal mouse prostate.
(2) Localization of acid phosphatase activity in nuclei of epithelial cells in mouse prostate after castration and implantation of stilbœstrol.
(3) Acid phosphatase in positive necrotic material and in nuclear membranes in mouse prostate autografts.
(4) and (5) Localization of acid phosphatase activity in dividing nuclei and nucleoli of resting cells in mouse prostatic autografts treated with methyl cholanthrene.
(6) Localization of acid phosphatase in stromal phagocytes in methycholanthrene-induced carcinoma of mouse prostate autografts in which glandular character has been lost.
(7) Alkaline phosphatase activity in basement membrane and stroma underlying acini in normal mouse prostate.
(8) Partial loss of alkaline phosphatase activity from normal site, and increase in connective tissue associated with the sheaths of hyperplastic smooth muscle of stroma in mouse prostate after castration or stilbœstrol implantation.
(9) Alkaline phosphatase activity in basement membrane, stroma and apices of cells and less intense in the nuclei of autograft of mouse prostate of three weeks.
(10) Localization of alkaline phosphatase activity in nuclei of epithelial cells in autograft of mouse prostate of two months

in the biochemical estimations, which can therefore give rise to most misleading conclusions. Some examples will illustrate this.

(1) Acid phosphatase. In Fig. 1 (mouse prostate), acid phosphatase can be seen localized mainly in the Golgi region of the epithelial cells. After castration (Fig. 2) the enzyme has become localized almost exclusively in the nuclei, the Golgi region having become negative. Similar results can be obtained by the implantation of stilbœstrol, and they can be reversed to normal by removal of the stilbœstrol or implantation of testosterone into the castrated animal. These changes, which must be of fundamental significance in the functioning of the prostate, would not be reflected at all in quantitative estimations of the acid phosphatase content of the prostate. A point of fundamental importance which emerges from these histochemical observations is that the distribution of acid phosphatase activity as between the nucleus and the Golgi region of the prostatic epithelial cell appears to be under control of the male sex hormone.

Furthermore, in histochemical preparations of some untreated subcutaneous homografts, the acid phosphatase can be seen to be, not in the normal epithelium but in the necrotic material within the lumena of the acini and in some connective tissue cells (Fig. 3). In such grafts which have been treated with methylcholanthrene, the reaction is confined to the dividing nuclei and is absent from the cytoplasm and from all but the nucleoli in the resting nuclei (Figs. 4 and 5). Again, none of these changes would be detectable biochemically. Fig. 6 shows a prostatic carcinoma which lost its glandular character after serial transplantations. Biochemical determinations showed a moderate content of acid phosphatase, but histochemical observations demonstrated that enzyme activity was absent from the tumour cells and was only present in the phagocytes of the stroma.

(2) Alkaline phosphatase. Alkaline phosphatase activity in the normal mouse prostate is largely restricted to the basement membrane, stroma underlying acini and in the endothelium of small blood vessels. It is entirely absent from the epithelium (Fig. 7). After castration, the reaction has largely disappeared from the basement membrane (Fig. 8), but has appeared in strength in the sheaths of the hyperplastic smooth muscle fibres of the stroma. The reaction has remained in the small blood vessels. A biochemical estimation of two such prostates may therefore show little change in total alkaline phosphatase activity despite these fundamental changes of distribution. A similar discrepancy is shown by Figs. 9 and 10. Fig. 9 is a prostatic autograft of a rabbit, and the alkaline phosphatase reaction can be seen mainly in the basement membrane, with a slight reaction in the nuclei and apices of some of the epithelial cells; in Fig. 10, however, which is an autograft of a shorter time, there is a reaction in the nuclei but none in the basement membrane[1].

It appears, therefore, that in experimental work on the prostate gland it is highly desirable to use histochemical preparations as a control of the biochemical estimations if the best use is to be made of the experimental material. This suggestion may also provide interesting results in the case of some other organs.

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Recovery of the Complementary Products of Mitotic Crossing-over

THE elegant analysis of mitotic crossing-over and segregation in *Drosophila melanogaster* by Stern[1] provided a model for comparison when an apparently similar process was observed by Pontecorvo *et al.* in diploid strains of *Aspergillus nidulans*, *Aspergillus niger* and *Penicillium chrysogenum*. The results obtained in *Aspergillus nidulans* have been entirely consistent with the interpretation by Stern; that is, mitotic crossing-over occurs such that at any one point only two of the four strands recombine and segregation of the centromeres is of the mitotic type[2].

Further support for this interpretation has now been obtained by the recovery, within a single diploid nucleus, of the reciprocal products of mitotic crossing-over. The technique used was based on recombination between alleles making use of the well-known position effect[3] usually shown by allelic mutants originated by independent mutation $\left(\frac{m_1 +}{+ m_2} = \text{mutant}, \frac{m_1\ m_2}{+\ +} = \text{normal}\right)$. We have assumed that, for the present purpose, crossing-over between alleles is not essentially different from that between non-allelic mutants.

A diploid *Aspergillus* (1) was prepared[4] heterozygous for a number of linked markers and carrying in the *trans* arrangement the two allelic mutants ad_{16} and ad_8. Phenotypes of the various haploid and diploid combinations of ad_{16} and ad_8 are shown in Fig. 1. (For other markers, see ref. 5.)

If the supposed mechanism of mitotic crossing-over is correct, then two distinguishable types (2 and 3) of adenine-independent recombinants would be expected following a single mitotic cross-over between the *ad* alleles. Type 2 would result from the inclusion within the same nucleus of the reciprocal products of crossing-over. Type 3 would result from the inclusion within the same nucleus of the chromatid carrying the wild type *ad* alleles with the non-cross-over chromatid.

Conidia of diploid 1 (adenine-requiring) were plated on a medium lacking adenine, and adenine-independent diploids selected. These represented only about 1 in 10^7 of tested nuclei. The majority of the adenine-independent types were shown, by recovery and out-crossing of haploids, to have either genotype 2 or 3.

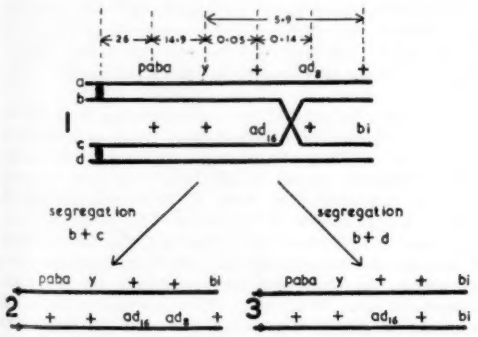

Fig. 1. Origin of recombinant nuclei. Distances in centi-Morgans

Strain	Phenotype on minimal medium
$ad_{16}+$	reduced growth
$+ad_8$	no growth
$ad_{16}\ ad_8$	no growth
$\frac{ad_{16}+}{+ad_8}$	reduced growth
$\frac{ad_{16}\ ad_8}{+\ +}$	full growth

The determination of genotype with respect to the *ad* alleles was made possible by the fact that ad_{16} and ad_8 determine slightly different phenotypes. The haploid double mutant $ad_{16}ad_8$ is phenotypically indistinguishable from the ad_8 type (that is, the most extreme mutant), but can be distinguished from it by out-crossing and recovering the less extreme type (ad_{16}). Similar results have also been obtained using alleles determining requirement for *p*-aminobenzoic acid[6].

These results support the mechanism of mitotic crossing-over and segregation as outlined above. Furthermore, the technique used has led to the recovery of nuclei carrying two mutant alleles in the *cis* arrangement. The great difficulty of succeeding in this with nutritional mutants of micro-organisms is apparent[7].

Whether one selects the complementary or non-complementary products of mitotic crossing-over, the technique outlined above offers an approach for the analysis of half-tetrads. One of us (R. H. P.) has already used the technique for this purpose.

This work is part of a programme of research supported by a grant of the Nuffield Foundation. One of us (R. H. P.) acknowledges a postgraduate grant from the Department of Scientific and Industrial Research.

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Vibrations of the Substrate and Stridulation in a Grasshopper

OBSERVATIONS made during experiments to determine the behaviour associated with stridulation in *Chorthippus parallelus* (Zett.) (Orthoptera, Acrididae) suggested that, in certain cases, females the tympanal organs of which had been destroyed were reacting to vibrations of the substrate caused by the act of stridulation in the male. Since it has been shown by Autrum[1] that Orthopteroid insects possess a receptor, the so-called sub-genual organ, which is sensitive to vibration, it was thought that preliminary experiments to determine whether a stridulating insect does produce any measurable vibration of the substrate would be of interest.

Adult mature males of *C. parallelus* were placed on hard-packed bare earth in a large metal tray mounted on thick sponge rubber. A 'Rotbermel' vibration pick-up, type *V.P.5*, was suspended in sponge rubber so that its tip just touched the soil, the centre of the insect arena being 15 cm. from the pick-up. The latter fed into a high-gain amplifier with variable band-pass filters, the output of which was displayed on one trace of a double-beam oscilloscope. The other beam of the oscilloscope was fed

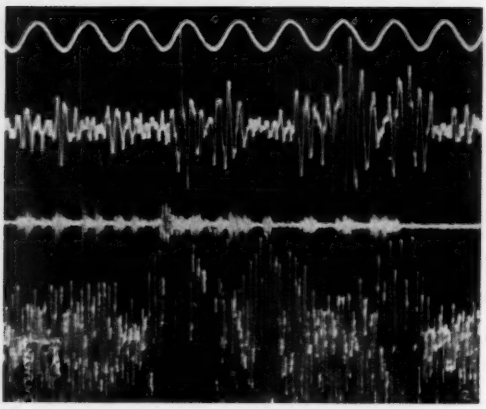

Fig. 1. Vibrations of 300 c./sec. set up by insect landing after a jump of 12 cm. Timing wave, 50 c./sec.

Fig. 2. Upper trace shows stridulation of male *Chorthippus parallelus*, and lower trace 500 c./sec. vibrations in substrate resulting from some of the sound pulses

from an audio-amplifier and a microphone, the latter being suspended over the insect arena. This arrangement permitted the direct observation and recording of stridulation and substrate vibrations produced by it.

The gain necessary to detect feeble vibrations produced high background noise; also, experiments had to be done at night, when extraneous vibration was at minimum level. The insects, with artificial heat and light, stridulated normally and also moved about freely in the arena both by walking and jumping. The former movement caused no detectable vibration, but the latter produced well-defined vibrations the frequency of which was 250–300 c./sec., with a maximum displacement of the order of 120 mμ. Fig. 1 shows an oscillograph of such vibrations, produced by the landing of an insect after a short jump of 10–12 cm. length.

Vibrations produced as a result of stridulation were so difficult to detect that it was at first thought that no measurable displacement was set up. But in a few cases, when the insect was within 6 cm. of the tip of the pick-up, definite displacements were observed; and although background noise was very high, vibrations clearly connected with stridulation were recorded. The lower trace of Fig. 2 shows an oscillograph of such vibration, the top trace being the sound pattern of the stridulation, showing the repetitive pulses typical of the species. It will be seen that the first few sound pulses do not appear to cause vibrations, although their amplitude is as high as the remaining pulses which do; the evidence available cannot explain this effect. The frequency of these vibrations is between 400 and 500 c./sec., and the maximum displacement represented is of the order of 20 mμ. This displacement is above the threshold, at the given frequency, of the sub-genual organ of Acrididae, as reported by Autrum and Schneider[2]; their work shows that at 400–500 c./sec. the organ in the hind leg of certain Acrididae (species not given) responds to substrate vibrations of the order of 10 mμ. Thus it seems probable that some Acrididae can detect the presence of a stridulating insect a short distance away, although the range will depend largely on the type of substrate and its attenuating effect on the vibrations.

It must also be remembered that the stridulation noise of Acrididae contains component frequencies up to about 10 kc./sec., and these may induce high-frequency vibrations in the substrate. These could not be detected in the present experiments as they are beyond the useful frequency-range of the apparatus. It is interesting to note, however, that it is at such high frequencies, according to Autrum and Schneider, that the sub-genual organs attain their maximum sensitivity; in Acrididae, for example, sensitivity at 3,000 c./sec. is of the order of 0·9 mμ. Against this must be set the fact that high-frequency vibrations would be subject to great attenuation by the substrate and therefore might not give a large increase in the possible range of detection.

Further work with more sensitive apparatus of wider frequency-range, with suitable precautions against extraneous vibration, is needed to clarify the possible range of communication by this method, and to investigate the possible existence of modes of vibration characteristic of particular stridulating insects.

I am indebted to Mr. Taylor-Smith, of the Department of Geophysics, Imperial College, for the loan of the vibration pick-up and amplifier.

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Plant Mitochondria and Salt Accumulation

The participation of a cytochrome oxidase system in salt respiration and salt accumulation was first suggested by Lundegårdh[1]. Robertson and Wilkins[2] presented quantitative evidence which was consistent with the hypothesis that the mechanism of accumulation depends on the cytochrome system. Recent studies have associated the cytochrome system with the mitochondria, and Robertson[3] suggested that mitochondria might be associated with the accumulation mechanism. Accumulation of cations in animal mitochondria has been demonstrated by Bartley and Davies[4], Macfarlane and Spencer[5] and Stanbury and Mudge[6]. Bartley and Davies also demonstrated that phosphate and organic anions were accumulated in mitochondria.

Mitochondria isolated by centrifugation from carrot and beet tissues and transferred from one isotonic solution to another containing a different concentration of chloride adjust themselves to a new internal chloride concentration with a half-time of about 3 min. Experiments on the time of adjustment have been used to calculate the apparent diffusion constant of salt in the mitochondrial membrane, assumed to be 200 A. in thickness as suggested by Farrant, Robertson and Wilkins[7]. The apparent diffusion constant is about 10^{-12} cm.²/sec., which is similar to that found in heart muscle sarcosomes prepared under similar conditions (K. W. Cleland, personal communication, 1954) and is of the order of magnitude expected for a lipo-protein membrane.

The mitochondria do not reach equality of concentration with the external solution, but maintain a higher internal concentration of both mobile cations and mobile anions. The results of a number of experiments have been grouped in Table 1.

Table 1. Concentrations of Sodium, Potassium and Chloride in Beet Mitochondrial Pellets in m.mole/l. Means, with standard errors and number of observations given in brackets

Na^+ concentration		K^+ concentration		Cl^- concentration	
External	Internal	External	Internal	External	Internal
0–6	22·8 ± 2·6 (12)	0–6	11·0 ± 0·8 (17)	0–2	4·9 ± 0·6 (11)
7–13	39·6 ± 3·9 (16)	7–13	20·6 ± 1·9 (5)	5–12	11·7 ± 0·7 (11)
		14–20	21·3 ± 1·6 (5)	13–20	16·9 ± 0·6 (18)
79–85	88·1 ± 2·6 (4)			45–47	38·7

The high concentration of mobile cations can be explained by a Donnan equilibrium with the immobile anions (proteins, phospholipids, etc.) in the mitochondria. Such an equilibrium would be accompanied by a lower internal concentration of chloride unless there were: (*a*) combination of either the mobile cations or mobile anions so that they are removed from solution; (*b*) two distinct phases, one with the mobile cations held by immobile anions and another with mobile anions held by immobile cations; or (*c*) a mechanism dependent on the oxygen uptake to accumulate the chloride against the concentration gradient.

While (*a*) and (*b*) cannot be excluded, (*c*) was investigated by comparing concentration of chloride maintained in the steady state with the oxygen uptake of the mitochondria. With no added substrate there was a positive correlation ($r = 0{\cdot}913$, $p < 0{\cdot}01$). Further, by using the apparent diffusion constant, the leakage-rate for a given concentration difference and hence the accumulation-rate required to maintain the concentration difference can be calculated. A concentration difference of 3 m.mole/l. would require an accumulation-rate of $4{\cdot}5 \times 10^{-6}$ gm. mol. chloride ion/pellet of 0·14 gm./hr. The oxygen uptakes observed were of the right order of magnitude to maintain this accumulation-rate if one anion was accumulated each time an electron traversed the cytochrome system, that is, about 1×10^{-6} gm. mol. oxygen/pellet/hr.

Thus the results are consistent with the hypothesis that the anions in the mitochondrion might be accumulated by the electron carrier of respiration acting as the anion carrier of accumulation. The mitochondria in the intact cell, capable of accumulating anions themselves, could act as vehicles for the passage of ions from cell-surface to vacuole.

This work was part of the joint programme of the Division of Food Preservation, Commonwealth Scientific and Industrial Research Organization, and Botany School, University of Sydney, and a fuller account will be published elsewhere[6].

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Occurrence of the Black Rat in Sewers in Britain

It had been supposed for a long time that the ship or 'black' rat, *Rattus rattus* L., did not occur in sewers in Britain. There was a record from the sewers of Lima, Peru[1], but no such records existed for the United Kingdom.

Recently, *R. rattus* has been taken alive from the sewers of three localities in England. The first of these was in Wandsworth Metropolitan Borough in the County of London. Sewermen had known for the past two years that "some of the rats down there were like bats without wings", and recently two live ship rats were caught and their identities confirmed.

I then suggested that the lack of records might be fortuitous, due merely to the lack of observation, and that other records would be made if a definite search were undertaken. Shortly after this, another live ship rat was taken from the sewers of Liverpool County Borough, and within the past few weeks, two live ship rats have been trapped in the sewers of Ramsgate Municipal Borough. Remains of dead ones have also been found.

Thanks are due to the local authorities mentioned, for their co-operation with this Ministry's staff.

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The Rostrum of *Centrocnemis* Signoret 1852

In the classification of the group Heteroptera, the number of segments in the labium was formerly considered to vary. Closer investigation has revealed, however, that all Heteroptera possess a labium composed of four segments.

In the Reduviidae all genera, with one exception, so far as is known, have only three visible segments in the labium, the first segment (or actual basal segment) being very feebly sclerotized and concealed within the head. The exception is the genus *Centrocnemis* Signoret (Hemiptera–Heteroptera: Reduviidae–Reduviinae). In this genus the basal segment is relatively large, strongly sclerotized and distinct. There are tubercles on it which may possibly be vestigial labial palpi. The labrum, moderately long and narrowly triangular, extends to just beyond the base of the second rostral segment. Its base is almost concealed by two of the tubercles on the first rostral segment, which converge over it.

Centrocnemis is included, at present, in the subfamily Reduviinae. In a forthcoming revision, I propose to remove it and to create a new subfamily for its reception, since, apart from its distinctive

rostrum, it has other characters which would justify this action.

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Light Sensitivity of the Aquatic Flatworm *Dendrocoelum lacteum*

We have measured in various parts of the spectrum the amounts of radiation necessary to elicit in the planarian *Dendrocoelum lacteum* a characteristic response, namely, movement away from a source of light[1]. In each trial, one animal was dropped into a square 'Perspex' tank (50 cm. × 50 cm., 10 cm. deep) filled with lake water, in front of a calibrated source of spectral radiation placed outside the tank (opal electric bulb, 'neutral' wedges and colour filter[2]). *D. lacteum*, being milky-white in colour, could readily be detected with a red electric torch against the background of black paper placed under the tank. After 3 min. the torch was switched on and it was seen whether the animal had moved at least 10 cm. away from the light source in approximately the right direction. If so, this was taken as a positive response. The animal's movements were too slow for the observations to be appreciably affected by the light of the torch. In control experiments in which the colour filter was replaced by a piece of opaque cardboard, the number of animals giving a positive response was insignificant.

Trials were made with a number of animals using various spectral bands in the 'visible' range and a band around 0·37μ in the near ultra-violet. For each spectral band, that intensity at which five out of the seventeen experimental animals responded was taken as the average threshold value. The individual thresholds varied considerably from one animal to another, and the accuracy which could be reached was markedly less than in the case of human vision. The sensitivity was a maximum in the neighbourhood of 0·5μ; this seems in general agreement with the maximum near 0·53μ found by Viaud[3] in studies made, at higher intensities, of the orientation reactions of planarians having eyes.

The spectral sensitivity curve was found to be roughly similar to that of rod vision in the human aphakic eye[4]—that is, an eye from which the lens has been removed. As the lens is responsible for the greater part of the light losses in the preretinal media of the human eye, the curve for *D. lacteum* must bear a general resemblance to the sensitivity curve of the human rod receptors. It should therefore also resemble the spectral absorption curve of the visual pigment rhodopsin; but it must be borne in mind that there is a discrepancy between the latter curve and the rod sensitivity curve at the violet end of the spectrum[5].

Relatively to the sensitivity to 0·51μ, the sensitivity to radiation of about 0·37μ was roughly a thousand times greater in *D. lacteum* than in the normal human eye with a lens. For this wavelength animals responded at an illumination at which they were quite invisible in the experimental tank to the dark-adapted, normal, human eye. The electric lamp itself, viewed through the 0·37μ filter, was then barely visible—although it would, of course, have looked much brighter to an aphakic eye. In parts of the spectrum other than the near ultra-violet, violet and blue, the animals, when the illumination was high enough to elicit a positive response, could generally just be seen by the dark-adapted, normal, human eye.

D. lacteum possesses two small but well-defined eyes, one on each side of the head. Taliaferro's experiments[6] on other species of planarians showed that the reaction studied here was mediated through the eyes—while also suggesting that the individual sense-cells may possess a remarkable directional sensitivity. Assuming, then, that in the present case the reaction is mediated entirely through the eyes, and that the diameter of the effective pupil of the eye is a circle 0·08 mm. in diameter, we calculate on the basis of absolute calibrations of the apparatus that five out of seventeen experimental animals responded in one series of experiments to an energy flux corresponding to about 40,000 quanta (λ = 0·52μ) per eye per sec., and in another series to about 4,000 quanta, or 15×10^{-9} erg, per eye per sec.

In the case of man, the minimum flux of radiation which must enter the pupil of the eye for a small continuous light source to be seen is of the order of 750 quanta (0·51μ), or 3×10^{-9} erg, per sec.[7]. Thus the organisms studied here would have an absolute sensitivity close to that of the human eye. Artificial light-detectors of similar sensitivity (photo-multipliers with ancillary apparatus) might weigh about a million times as much as one specimen of *D. lacteum*. As stated, however, this discussion of absolute values rests on the assumption that the reaction is mediated entirely through the eye; experiments are in preparation to verify this assumption directly.

We are greatly indebted to Mr. H. C. Gilson, director of the Windermere Laboratory of the Freshwater Biological Association, for facilities to carry out these experiments in his laboratory. The apparatus used was acquired through the support of the Nuffield Foundation and the Medical Research Council. One of us (F. H. C. M.) is the recipient of a Nuffield Foundation Biological Scholarship.

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An Asymmetrical Response of Teleost Melanophores

Ballowitz[1], Wyman[2] and others have described several nerve fibres innervating the individual melanophores of Teleosts, and it is now generally accepted that these nerves are of autonomic origin. Whether the melanophore innervation is single, involving aggregating fibres only, or double, including an antagonistic set of dispersing fibres, is still a matter of opinion (Parker[3]).

As a rule, section of a few melanophore nerve fibres in a white-adapted teleost fish causes an area of the related melanophores to disperse, the melanin granules being symmetrically distributed in the melanophore processes. Each of the surrounding

innervated melanophores remains symmetrically aggregated. In the course of numerous experiments on the minnow (*Phoxinus phoxinus* L.), I have repeatedly observed melanophores on the border of a denervated area with processes directed towards the fully denervated melanophores in the dispersed state, and processes directed towards the innervated area in a much more aggregated state (Fig. 1).

This asymmetrical response in Teleosts has not, to my knowledge, been previously reported. It is not peculiar to the minnow, but is easily seen, for example, on the borders of denervated melanophore areas in *Gobius paganellus* (Fig. 2) and *Gasterosteus aculeatus* (Fig. 3).

Several workers have made detailed studies on denervated teleost melanophores (cf. Parker[3]), especially in *Ameiurus nebulosus*, without reporting any marginal asymmetrical response. High magnification shows the response to be present in this Teleost, though it occurs less frequently than in the other Teleosts investigated. Fig. 4 shows at *a* the asymmetrical response in a large dermal melanophore and at *b* the response in two of the smaller epidermal melanophores of *Ameiurus*.

If the nerve fibres innervating the melanophores are entirely aggregating, then the asymmetrical response takes place because those fibres innervating the more dispersed side of the melanophore have been severed, whereas those serving the more aggregated side continue to operate in the white-adapted fish. However, Parker[3] believes that the teleost melanophore innervation is double and that nerve section causes an active stimulation of the dispersing fibres without affecting the aggregating ones. If this is so, then the asymmetrical response is caused by the dispersing fibres activating one part of the melanophore, and aggregating fibres antagonistically activating another part of the same melanophore. In either case, if the melanophore is a single effector cell, the situation arises of such a cell doing one thing in one half and a different thing in the other.

Parker[3] has suggested that the double innervation of melanophores involves the release of adrenaline or acetylcholine at the nerve-fibre endings, just as in other autonomically innervated effectors. If this is so, it seems that these neurohumours produce two localized effects on the surface of the melanophore. It seems probable that melanophore effector cells are so comparatively large that several nerve fibres have, of necessity, become the established innervation in evolution, to bring about a complete response.

A more detailed account of teleost melanophore denervation experiments will be published elsewhere. Acknowledgments are due to Dr. E. G. Healey for supervision and to the Medical Research Council for a research scholarship.

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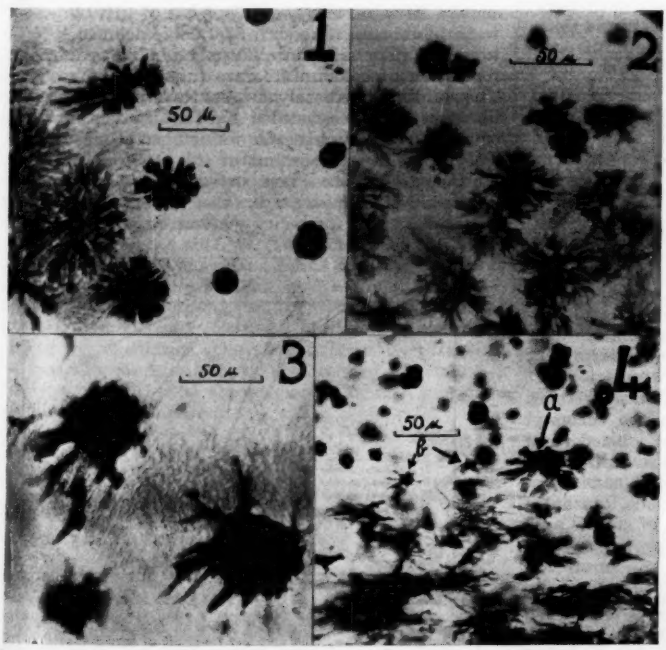
Influence of Dietary Antibiotic Supplements on the Visceral Weights of Pigs

Gordon[1] showed that a dietary antibiotic supplement of 50 parts per million of procaine penicillin or terramycin in the food of chicks produced a significant reduction in the weight of the small intestine. The weights of the liver and spleen were not affected.

The present results were obtained from 75 Large White pigs, slaughtered at approximately 200 lb. live-weight, in an antibiotic feeding experiment. The pigs were arranged in fifteen pens of five, three pens being fed a basic ration, six the basic ration plus various doses of aureomycin hydrochloride, and six the basic ration plus various doses of procaine penicillin; the average amount of both antibiotics was 30 parts per million in the food. Table 1 shows the mean weights of the evacuated sections of the digestive tract, liver and spleen in control, aureomycin- and penicillin-fed animals. Table 2 gives the significance levels of the various differences.



The weights of the stomach, cæcum and large intestine were not significantly affected by the administration of either antibiotic. The small intestine was significantly lighter in the aureomycin-fed animals, but there was only a slight, non-significant, reduction in this weight in the penicillin-fed animals. Aureomycin also produced a significant reduction in the weight of the spleen, which was not found in the penicillin-fed animals. The livers of the penicillin-fed animals were considerably heavier than those of the controls, whereas aureomycin pro-

Table 1. Average Weights (in grams) of Stomach, Small Intestine, Cæcum, Large Intestine, Liver and Spleen of the Control, Aureomycin- and Penicillin-fed Animals

Treatment	No. of pigs	Stomach	Small intestine	Cæcum	Large intestine	Liver	Spleen
Control	15	865	2,092	179	1,712	2,121	153
Aureomycin	30	856	1,823	164	1,715	2,044	133
Penicillin	30	885	1,973	176	1,661	2,296	147

Table 2. Significance Levels of the Differences between Control and the Aureomycin Group, between Control and the Penicillin Group and between the Aureomycin and Penicillin Groups

Comparison	Stomach	Small intestine	Cæcum	Large intestine	Liver	Spleen
Control v. aureomycin	N.S.	+++	N.S.	N.S.	N.S.	++
Control v. penicillin	N.S.	N.S.	N.S.	N.S.	+	N.S.
Aureomycin v. penicillin	N.S.	++	N.S.	N.S.	+++	+

N.S. = Not significant; + = $p < 0.05$; ++ = $p < 0.01$; +++ = $p < 0.001$

duced a (non-significant) reduction in the weight of the liver.

The total weight of the organs considered was considerably greater in the penicillin-fed animals than in those fed with aureomycin. This may partially explain the significantly greater dressed-carcass weights (allowing for live weight) of the aureomycin-fed animals compared with the penicillin-fed animals, noted in this and two other experiments by Harrington and Taylor[2].

The differing effects of aureomycin and penicillin on the weights of the small intestine, liver and spleen suggest that their modes of action may be different; histological examination of the livers and spleens has, however, not revealed any consistent changes to which the variations in weight of these organs could be attributed.

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Ionization in Fatty Acid Monolayers on Pure Water

Experiments recently carried out in this laboratory suggest that previous determinations of some important properties of monolayers of long-chain fatty acids on water surfaces have been misinterpreted. Former measurements of force–area characteristics[1–3] and surface potentials[4] show well-defined changes occurring at about the *p*H at which the carboxyl group is expected to be appreciably ionized, and these changes have been ascribed to the ionization[2]. We have found that the effects can be caused by impurities in the substrate and that, in fact, ionization has much less effect on the properties of stearic acid monolayers than has been thought previously.

Fig. 1 shows results from $(\pi - A)$ measurements over the *p*H range 2–9 with stearic acid films on water of increasing degrees of purity. In the graph, σ_0, the area/molecule at 'zero' compression (that is, at the pressure at which an increase in film pressure is first observed as the film is compressed) (unpublished results) is plotted against *p*H. The values of σ_0 were obtained from $(\pi - A)$ curves determined in the usual manner on a Langmuir–Adam surface balance. The *p*H of the substrate was adjusted by the addition of hydrochloric acid or ammonium hydroxide, and no attempt was made to keep the ionic strength constant. Measurements made before and after each $(\pi - A)$ determination showed that the *p*H remained constant over this time to within ± 0.1 *p*H unit. Films were left for at least five minutes on the water surface before they were compressed.

On the purest water, there was no significant variation of the $(\pi - A)$ curves over the whole of the *p*H range. Thus σ_0 remains constant, as seen in curve 1 (Fig. 1). The water used in this experiment was derived from a very soft tap water (Melbourne city supply) by distillation in a tin-lined still and then in an all-'Pyrex' still. The latter consisted of a 3-litre boiling flask surmounted by a splash head connected to a vertical water condenser by an almost horizontal air condenser 22 cm. long. The outlet from the splash head was at least 45 cm. above the level of the water in the boiling flask. The electrical conductivity of the purified water was 1×10^{-6} Ω^{-1} cm.$^{-1}$.

Curves II, III and IV were obtained with the successive distillates from a typical hard water obtained from a limestone quarry near Geelong (Victoria). The distillations were carried out carefully in a 'Pyrex' still of the same design and dimensions as that used for the second distillation of the Melbourne water. Curve V was obtained with *M*/2,000 calcium chloride solution. Curves II–V all show a decrease in σ_0 with increase of *p*H. Previous work has shown that with *M*/2,000 calcium ion solutions the depression in σ_0 at *p*H 6 is caused by the formation of calcium stearate (unpublished results). The results immediately suggest that the behaviour of films on the once-distilled hard water (curve II) is caused by alkaline earth impurities in the water. The total calcium content of the Geelong and Melbourne water sources is reported to be 68 and 2 parts per million respectively[5], the latter value being particularly low for a city water supply.

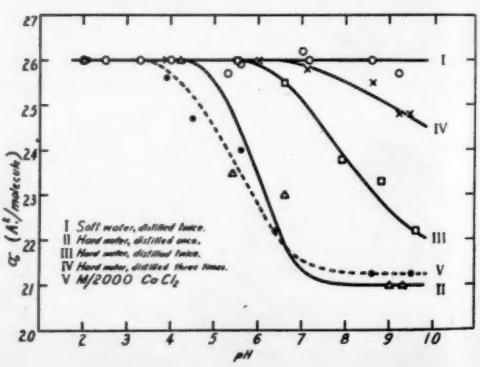

Fig. 1. Effect of the purity of water on monolayers of stearic acid. Variation of σ_0, the area per molecule at zero compression, with *p*H

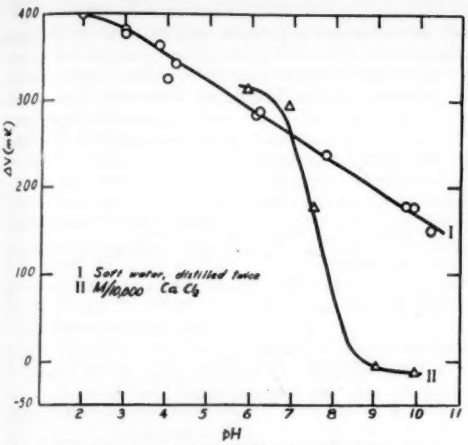

Fig. 2. Dependence of surface potential on *p*H for compressed monolayers of stearic acid on pure water and on a dilute solution of calcium chloride

The increase in purity produced by successive distillations of the hard water is seen from the way in which curves III and IV approach curve I. However, even after the third distillation, sufficient calcium is still present to cause a slight depression in σ_0 at high *p*H values.

Surface potential measurements, made with a radioactive electrode under the same conditions as the $(\pi - A)$ curves, gave the results presented in Fig. 2. The values of ΔV are the potentials, no longer dependent upon pressure, obtained when the film is compressed to an area/molecule less than σ_0. The films behaved reversibly, and the measurements were reproducible to within about 10 mV. With the purest water, ΔV decreases apparently linearly from + 400 mV. at *p*H 2 to + 170 mV. at *p*H 10. With a very dilute solution of calcium chloride, ΔV drops suddenly at *p*H 7 to a slightly negative value at *p*H 9 (curve II, Fig. 2). This curve is strikingly similar to previously published ($\Delta V - p$H) curves[4] in which the sudden drop in ΔV has been ascribed to ionization. This similarity suggests that unsuspected impurities reacting with the acid to form a soap are also responsible for the more negative potentials observed by other workers at high *p*H values. These workers, however, used buffered solutions of much greater ionic strength than those used in our own experiments.

The results show that of itself ionization in the monolayer has no appreciable effect on the $(\pi - A)$ characteristics of stearic acid, and a much smaller effect on the surface potential than previously supposed. It is also demonstrated that if a hard water is to be purified by distillation, the process must be carried out carefully and repeatedly before the effects of dissolved impurities on the properties of acid monolayers can be eliminated.

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Proton Magnetic Resonance Spectra of Coals

Proton magnetic resonance spectra can give information about the arrangement of the hydrogen atoms in a solid[1]. Preliminary measurements have been made which suggest that this method may provide useful information about the distribution of hydrogen atoms in coal.

Samples were prepared from hand-selected lumps of bright coals containing more than 50 per cent vitrain. The samples were ground into cylinders of 6·25 mm. diameter × 3 cm. long, the axis of the cylinder lying in the bedding plane. Part of the inherent moisture content of the samples was removed by heating them to 80° C. under a pressure of 0·2 mm. of mercury for 4 hr. The samples were then sealed into glass tubes to prevent resorption of moisture. Nuclear resonance measurements were made at 90° K. using the apparatus described by Richards and Smith[2] and by Pratt and Richards[3].

The second moments of the proton resonance absorption lines were obtained for three samples and are given in Table 1, together with the constitution of the coals. A slight anisotropy of line shape with orientation of the sample in the magnetic field was observed with the Llandebie, but not with the other coals.

Table 1

Coal	N.C.B. Code No.	Percentage constitution				Second moment (gauss)[2]
		Moisture	Carbon	Hydrogen	Ash	
Llandebie	100*a*	1·5	92·6	2·8	1·1	16
Monk Bretton	602	3·2	83·1	5·2	0·4	19½
Langwith	902	4·8	79·2	5·3	1·2	21½

One interpretation of the variation in second moment would be in terms of a variation in the ratio of the number of hydrogen atoms present in saturated hydrocarbon chains or rings to the number of hydrogen atoms attached to aromatic or graphitic structures. Proton resonance spectra of aromatic hydrocarbons have second moments[4] of about 10 gauss[2] and aliphatic hydrocarbons give spectra with second moments[5] of about 26 gauss[2]. On this interpretation the relative proportion of aliphatic protons increases as the carbon content of the coal decreases. X-ray diffraction investigations[6] on coal samples suggest that the graphitic or aromatic structure increases with increasing rank.

One of us (P. C. N.) wishes to thank the Director-General of Research, National Coal Board, for permission to publish this communication; the views expressed are not necessarily those of the Board.

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Excitation Processes and the Theory of the Arc Discharge

No satisfactory theory exists to account for the current transfer at the cathode of an arc the cathode material of which has a low boiling point, such as mercury or copper. Whereas thermionic emission can account for the mechanism of arcs with cathodes of high boiling point, such as carbon and tungsten, this seems highly improbable for substances which boil far below their emitting temperature. Field emission of electrons[1], current transfer by positive ions only[2], and other suggestions[3] have been made; but they cannot account for both the observed high current densities[4] of order 10^6 A./cm.^{2} and the low cathode fall, which can be smaller than the ionization potential of the cathode material[5].

A new theory is proposed in which electrons are released from the cathode by excited atoms the potential energy of which exceeds the work function. The intensely luminous 'cathode spot' suggests that, immediately above the current-carrying area of the cathode, there is a region of excited metal vapour the density of which is many orders of magnitude greater than elsewhere in the arc. There is a net flow of neutral atoms through this region which can be regarded as the difference between the gross cathode evaporation and the return of atoms to the cathode by back-scattering. Most of the returning atoms will be excited, but because of the short distance they have to travel they will reach the cathode surface before they have time to radiate. Consequently they will behave like metastable atoms, which are known to cause emission of electrons with a very high yield[6]. The emitted electrons gain energy in the cathode fall, which is so small that they can only produce excitation of the vapour and then carry the arc current into the adjoining positive column. Ionization in the vapour will occur by collisions between excited atoms. The positive ion current to the cathode need only be sufficient to provide the space charge for the cathode fall and supply energy for evaporation. The presence of a foreign gas should not affect appreciably this cathode mechanism.

Known measurements[7] on a mercury arc give a rate of evaporation of 3×10^{-4} gm./coulomb; for a current density of 10^4 amp./cm.^{2}, this is equivalent to 10^{24} atoms/cm.^{2} and sec. The gross evaporation and hence back-scattering may be at least an order of magnitude greater, namely, 10^{25} atoms/cm.^{2} and sec. If most of the latter are excited, such a flow should be ample to release 10^4 amp./cm.^{2} of electrons from the cathode.

The cathode fall can be estimated from a balance of the rates of production and loss of excited states in the cathode spot. The losses include radiation, ionization, diffusion towards the positive column and, most of all, back-diffusion to the cathode. If the latter accounts for at least half the total loss, then the cathode fall would be less than twice the principal excitation potential of the cathode vapour. For mercury this excitation potential is 4·9 V., and thus the cathode fall should be rather less than 10 V., as observed.

The proposed model is in accord with a previous theory of the retrograde motion of cathode spots in transverse magnetic fields[8]. In addition, it is proposed that the high current density in arc spots is due to the self-magnetic field operating in the ionized vapour. A detailed treatment of the contraction and the emission processes will appear in the near future.

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Optical Aspherizing by Vacuum Evaporation

J. Strong and E. Gaviola[1] described the preparation of optical aspherics by vacuum evaporation. They used layers of aluminium to parabolize mirrors, but found that with thickness greater than 5λ the coating began to show a bloom and scatter light. Apparatus for the production of refracting elements by this method was described by L. G. Schulz[2]; Schulz used lithium fluoride and was able to produce aspheric films giving a retardation $[(n-1)t]$ of up to 2·5λ. At that thickness the films began to peel off. The retardation could be doubled by covering the lithium fluoride film with a layer of collodion and evaporating on to this another layer of lithium fluoride.

We have now prepared zinc sulphide films giving retardations up to 30–40λ mercury green light, the upper limit of thickness not having yet been reached. The films did not show any signs of weathering or instability over periods of one to two months. Longer-term experiments are in progress. There was also no change in optical thickness.

Using ordinary quality zinc sulphide containing appreciable impurities (including more than 1 per cent silicon), the films are yellowish when viewed by transmission; but a layer giving about 30λ retardation would transmit about 85 per cent of the light in the 5000–7000 A. region incident upon it, allowing for surface reflexion losses. Films made from a much purer sample of zinc sulphide are less coloured. This material is being investigated further.

The reflexion losses at the zinc sulphide – air and zinc sulphide – glass interfaces are considerable, but they can be reduced by using anti-reflexion coatings. Two-layer coatings for each interface were computed using zinc sulphide and magnesium fluoride, and were found to work well in practice.

The present apparatus is similar in principle to that of Schulz. The distance between the boat and the plate or lens on to which the film is evaporated is about 11 in. Glass plates of diameters up to 4 in. can be accommodated at present. The boat can be recharged several times, so that a film of retardation up to 10λ can be deposited without breaking the vacuum.

The films produced show very good revolution symmetry. In a typical case, at a point of 25λ retardation which lay on a circle of diameter 8 cm., the eccentricity was 0·05λ retardation. The direc-

tional dependence of the rate of evaporation of the source was found to be reproducible to 1 part in 1,000.

The first attempt at cutting a template to give a certain aspherization yielded a film in which the maximum departure from the desired retardation was 0·3λ. The maximum retardation of this film was 6λ. This error, which depends a lot on the type of aspherizing required, could be eliminated by suitable adjustments of the template shape. It was found that if the template was removed and then replaced again, the resultant aspherizing could vary by 5 parts in 1,000. This could be remedied by a better mounting arrangement for the template.

It is hoped to publish a more detailed description of this work elsewhere.

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The Yellow Emission Line of the Solar Corona

In 1942, Edlén[1] identified twenty-three emission lines in the solar corona. One of the two doubtful identifications in the list, that of the yellow line λ 5694 with the transition $2p^3\ {}^2P_{1\to 0}$ in Ca XV, presents an especially interesting problem, because the ionization energy of Ca XV (814 eV.) exceeds that of every ion known to produce coronal lines. If Edlén's identification were to prove correct, it would provide an important clue to the mystery of coronal excitation.

In 1947, Waldmeier[2] discovered a companion line at λ 5445, which he later[3] attributed to the transition $2p^3\ {}^2P_{2\to 1}$ in Ca XV. Edlén had pointed out earlier[4] that a companion line ought to appear in the visible spectrum, and its discovery supported his original identification.

Shklovsky[5] showed, however, that the intensity ratio measured by Waldmeier, $I(5694)/I(5445) = 6$, could not be explained by any known mechanism for exciting the levels in Ca XV. A thorough semi-theoretical analysis by Garstang[6] of the ground configuration in the long isoelectronic sequence headed by C I cast further doubt on the identifications. Garstang's predicted wave-lengths, 5380 A. for the transition $2 \to 1$ and 5480 A. for the transition $1 \to 0$, did not differ greatly from the observed wave-lengths; but the internal consistency of the analysis seemed to exclude an error of more than 50 A. in either of the predicted wave-lengths.

Recently, two new pieces of evidence have come to light. From measurements of line-widths, Mme. Pecker, Billings and Roberts[7] derived an atomic weight of 40 ± 2 for the ion producing the yellow line. They also discovered that Waldmeier's line, λ 5445, is blended with a Fraunhofer (absorption) line. By correcting for this effect, they were able to reduce the intensity ratio from 6 to 1·6, which is in satisfactory agreement with Shklovsky's theory.

Although the results obtained by Mme. Pecker, Billings and Roberts do not actually contradict Garstang's conclusion, they do raise the question whether the small discrepancies between the predicted and the observed wave-lengths may not be due to some imperfection in the underlying theory. I have recently completed a calculation which suggests that in fact they are.

The chief defect of the theory used by Garstang is its approximate treatment of configuration mixing. The theory takes account of some of the effects of configuration mixing, but neglects others which are significant when the spin-dependent interactions compete seriously with the electrostatic interactions, as in Ca XV. For example, consider the electrostatic coupling between the levels of two ^3P terms, the upper one inverted, as in the accompanying diagram. Configuration mixing depresses the unperturbed levels of the lower term. On the approximate theory used by Garstang, the three displacements are equal. Consequently, the spacing of the perturbed levels is the same as the spacing of the unperturbed levels. In reality, the three displacements are unequal, being inversely proportional (roughly) to the intervals between corresponding unperturbed levels in the two terms.

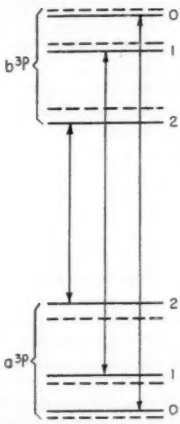

Fig. 1. Levels of two coupled ^3P terms, the upper one inverted. The solid horizontal lines are the unperturbed levels. Levels connected by the vertical lines repel each other, the displacements being roughly proportional to the reciprocals of the intervals between corresponding levels in the two terms. The broken lines are the perturbed levels

A theoretical argument shows that in Ca XV the ground configuration $(1s^2)\ (2s^2)\ (2p^2)$ interacts weakly with all the higher-lying configurations except $(1s^2)\ (2p^4)$. We may therefore identify the energy-levels of the ground configuration with the smallest five eigen-values of a tenth-order matrix the elements of which connect the levels of $(1s^2)\ (2s^2)\ (2p^2)$ and $(1s^2)\ (2p^4)$. This matrix, which reduces to a pair of fourth-order matrices and a second-order matrix, involves nine undetermined parameters. One of these is a trivial additive constant to the energy-levels; three can be eliminated by a simple theoretical argument; and I have evaluated two more by extrapolation along the isoelectronic sequence. In addition, I have taken over all Garstang's extrapolated parameters, and these complete the list. Thus the present calculation differs from Garstang's only in the underlying theory, and not in the choice of parameters.

The results of the calculation are: $E(^3P_1) - E(^3P_0) = 5650$ A., as compared with 5694 A. for the yellow line; and $E(^3P_2) - E(^3P_1) = 5456$ A., as compared with 5445 A. for Waldmeier's line. In view of the approximate character of the calculations, the agreement is satisfactory, and tends to confirm the identifications of Edlén and Waldmeier.

A detailed account of this work will appear in the *Monthly Notices of the Royal Astronomical Society*.

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Conductivity induced in Mica by X-Rays

Although mica is not recognized as one of the highly insulating materials (its specific volume conductivity is quoted in standard reference books as between 10^{-14} and 10^{-17} ohm-cm.$^{-1}$ at 20° C.), its behaviour under X-irradiation is of interest in comparison with the organic plastic insulating materials which we have studied[1].

The experiments on mica were made with sheets 0·15 mm. thick, using the d.c. amplifier technique which we have previously described[1]. Mica shows relatively low values of induced conductivity, of the same order as those in polymethyl methacrylate and amber. The conductivity in mica is not greatly dependent on temperature, and in this respect also it is similar to 'Perspex' and amber. The equilibrium induced conductivity is almost linear with dose-rate, and the recovery after irradiation is rapid. These characteristics lead us to place mica in Class 1 of the insulators we have studied[2], together with plasticized 'Perspex' and amber. (Class 2 includes polystyrene, polytetrafluoroethylene, and unplasticized 'Perspex'.)

Dose-rate dependence. In the relationship between equilibrium induced current i_x and dose-rate R,

$$i_x \propto R^{\Delta}, \qquad (1)$$

we find $\Delta = 0{\cdot}95 \pm 0{\cdot}05$ for mica over the range R = 2–64 r./min. and between − 20° and 100° C. This value does not exclude the possibility of Δ being exactly 1; but it is likely that several of the materials generally believed to have $\Delta = 1$ do in fact have values of Δ slightly less than unity; recent measurements have indeed shown this to be so for red 'Perspex'. Physically, this deviation from unity means that the distribution of traps in depth (energy) is correspondingly non-uniform, with a greater number of shallow traps[3]. Accurate values of Δ are difficult to determine for mica, due to the large static conductivity. There is no doubt, however, that mica is among those materials with Δ closest to unity, and therefore on the basis of an electron-trapping model[3] the distribution of traps is likely to be comparatively uniform.

Dependence on temperature. Fig. 1 shows the graphs of log (conductivity) of mica plotted against the reciprocal of absolute temperature. The resulting straight lines are of slope proportional to the activation energy, according to the general formula,

$$\sigma = \sigma_0 \exp(-W/kT). \qquad (2)$$

In the case of static conductivity (that is, with no incident radiation), $W = 0{\cdot}45$ eV. This is a considerably lower value than those obtained for the plastic insulators studied (1·1–1·5 eV.), and to some extent correlates with the relatively high static conductivity of the mica.

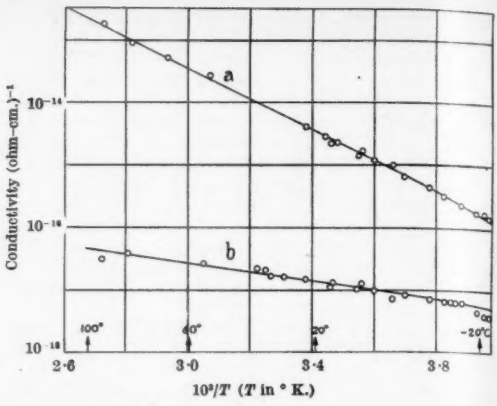

Fig. 1

For the equilibrium induced conductivity (Fig. 1*b*) at R = 7 r./min., the slope corresponds to $W = 0{\cdot}18$ eV. The current therefore increases by a factor of about 10 between 0° and 100° C. If we assume a slightly non-uniform distribution of traps corresponding to $\Delta = 0{\cdot}95$, the theoretical increase is by a factor of 30. (If $\Delta = 1$, the increase would be very small indeed.) The agreement with this model is reasonable.

Since the induced current in mica is seen as a small increase above the 'dark current', accurate measurement was achieved at the low dose-rates only by cooling the vacuum chamber and the sample to about − 20° C. by means of solid carbon dioxide. The dark current was thereby reduced by a much greater factor than the induced current, and the value of i_x could be determined.

Decay of induced current. The induced current falls rapidly at the end of irradiation to less than one-tenth of the equilibrium value. We were not able to determine whether there was any subsequent longer-term decay of residual current, as the recovery appeared to be complete within a few seconds.

Comparison with other results. Coleman (private communication, 1954) has reported a value of Δ equal to 1, and the actual values of induced conductivity measured by him[4] accord well with those given above. He finds an activation energy of zero for induced conductivity, which is in general accordance with our low value. The cause of this difference may lie in different degrees of impurity in the mica; but it is probably significant that the values of activation energy of insulators measured by different observers, or by the same observers on different samples of a given material, are not in such good agreement as are the values of Δ.

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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Tuesday, April 12

INSTITUTION OF THE RUBBER INDUSTRY (at the Royal Society of Tropical Medicine and Hygiene, 26 Portland Place, London, W.1), at 6.30 p.m.—Annual General Meeting.

Wednesday, April 13

INSTITUTE OF PETROLEUM (at 26 Portland Place, London, W.1), at 5.30 p.m.—Mr. J. W. Platt: "The Oil Industry—Its Place in the World and Its Future".*

BRITISH INSTITUTION OF RADIO ENGINEERS (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Discussion meeting on "The B.B.C. V.H.F. F.M. Sound Broadcasting Service".

Thursday, April 14

PHYSICAL SOCIETY, LOW TEMPERATURE GROUP (in the Science Museum Lecture Theatre, Exhibition Road, London, S.W.7), at 4.30 p.m.—Dr. L. C. Jackson and Dr. E. Mendoza: "Problems in the Storage and Transport of Liquid Hydrogen and Helium".

ASLIB (at the Royal Society of Arts, 8 John Adam Street, Adelphi, London, W.C.2), at 6 p.m.—Mr. C. H. Gibbs-Smith: "Classification and Storage of Pictorial Material".

INSTITUTE OF METALS, LONDON LOCAL SECTION (at 4 Grosvenor Gardens, London, S.W.1), at 6 p.m.—Annual General Meeting, followed by a Discussion on "Recent Developments in Special Machining Techniques".

Thursday, April 14—Friday, April 15

INSTITUTE OF PHYSICS, EDUCATION GROUP (at 47 Belgrave Square, London, S.W.1), at 10 a.m. daily—Annual Conference.

Thursday, April 14—Sunday, April 17

SOUTH-EASTERN UNION OF SCIENTIFIC SOCIETIES (at Folkestone)—Sixtieth Annual Congress.

Thursday, April 14—Monday, April 18

BRITISH PSYCHOLOGICAL SOCIETY (at the University, Durham).—Annual Conference.

Saturday, April 16

At 9.30 a.m.—Annual General Meeting.

Friday, April 15

INSTITUTE OF METALS, OXFORD LOCAL SECTION (in collaboration with the METAL PHYSICS COMMITTEE, in the Lecture Theatre of the Clarendon Laboratory, Parks Road, Oxford), at 11 a.m.—Informal Discussion on "Fatigue"; 2.30 p.m.—Brain's Trust Session.*

INSTITUTE OF NAVIGATION (at the Royal Geographical Society, 1 Kensington Gore, London, S.W.7), at 5 p.m.—Commander E. M. Penton, D.S.C., R.N.: "A Voyage Through the North-West Passage".

INSTITUTION OF MECHANICAL ENGINEERS (at 1 Birdcage Walk, Westminster, London, S.W.1), at 5.30 p.m.—Dr. J. S. Halliday: "Surface Examination by Reflection Electron Microscopy".

Friday, April 15—Saturday, April 16

BIOCHEMICAL SOCIETY (joint meeting with the ASSOCIATION OF CLINICAL BIOCHEMISTS, in the Department of Biochemistry, The University, Liverpool), at 11 a.m.—Scientific Papers.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

DEPARTMENTAL LECTURER (with special qualifications in mathematics and experience of school-teaching) IN THE UNIVERSITY DEPARTMENT OF EDUCATION—The Secretary of the University Department of Education, 17 Brookside, Cambridge (April 15).

LECTURER IN THE DEPARTMENT OF BACTERIOLOGY—The Registrar, The University, Liverpool (April 15).

LECTURER or SENIOR LECTURER IN MATHEMATICS, and LECTURERS or SENIOR LECTURERS (2) IN PHYSICS and MECHANICS, at Britannia R.N. College, Dartmouth—The Secretary, Civil Service Commission, 6 Burlington Gardens, London, W.1, quoting 4443/55 (April 15).

ASSISTANTS IN MATHEMATICS—Secretary of University Court, The University, Glasgow (April 16).

LECTURER (with a university degree in pharmacology, or a degree in physiology or pharmacy, with additional special training in pharmacology) IN PHYSIOLOGY AND PHARMACOLOGY—The Clerk and Treasurer, Dundee Technical College, 40 Bell Street, Dundee (April 16).

SENIOR ASSISTANT PHYSICIST (with an honours degree in physics and previous experience in hospital physics) IN THE RADIOTHERAPY and X-RAY DIAGNOSTIC DEPARTMENTS—The Personnel Officer, St. Thomas's Hospital, London, S.E.1 (April 16).

UNIVERSITY LECTURER IN THE DEPARTMENT OF GEOLOGY—Appointments Committee of the Faculty of Geography and Geology, Department of Geography, Cambridge (April 18).

RIVER INSPECTOR (with a university degree in chemistry, and member of the Institute of Sewage Purification), within the area of the Forth River Purification Board—The Clerk to the Board, Forth River Purification Board, County Offices, Viewforth, Stirling (April 20).

TECHNICAL ASSISTANT (female) (preferably with experience of radioactive techniques), to assist in clinical and experimental research work and treatments using radioactive isotopes—The Secretary, Mount Vernon Hospital, Northwood, Middlesex (April 22).

CHAIR OF INORGANIC CHEMISTRY, tenable at the Imperial College of Science and Technology, London, S.W.7—The Academic Registrar, University of London, Senate House, London, W.C.1 (April 28).

ASSISTANT LECTURER IN BACTERIOLOGY, and an ASSISTANT LECTURER IN MATHEMATICS—The Registrar, University College of South Wales and Monmouthshire, Cathays Park, Cardiff (April 30).

ASSISTANT LECTURER (with special qualifications in organic chemistry) IN CHEMISTRY—The Registrar, The University, Manchester 13 (April 30).

ASSISTANT LECTURER (with a good honours degree, and preferably with a knowledge of Greek and German) IN PHILOSOPHY—The Registrar, King's College, Strand, London, W.C.2 (April 30).

CHAIR OF MECHANICAL ENGINEERING—The Registrar, The University, Sheffield 10 (April 30).

CHAIR OF PHYSICAL METALLURGY—The Registrar, University College, Singleton Park, Swansea (April 30).

LECTURER IN ORGANIC CHEMISTRY at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, April 30).

LECTURER (with a good honours degree in biochemistry or organic chemistry (natural products)) IN BIOCHEMISTRY—The Registrar, King's College, Strand, London, W.C.2 (May 9).

TECHNICAL OFFICER (paint chemist) (with at least a recognized B.Sc. degree in chemistry or physics or an equivalent qualification and a thorough knowledge of paint raw materials, paints and the testing and manufacture of paint), for duties which include the preparation of specifications and the testing of paints and paint materials—The Secretary, South African Bureau of Standards, Private Bag, 191, Pretoria, South Africa (June 15).

AGRICULTURAL OFFICER (Tobacco) (with a university degree in agriculture or a related subject, and a knowledge of field experimentation, and practical experience of the cultivation of tobacco, including flue-cured tobacco) in H.M. Oversea Civil Service, Uganda, to make a survey of tobacco potentialities in Uganda, and to be in charge of all investigational work on this crop—Director of Recruitment, Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting BCD.63/9/01.

CHAIR OF PHYSICS, and CHAIR OF GENERAL CHEMISTRY, at the Royal College of Medicine, Baghdad, Iraq—The Director, Personnel Department, The British Council, 65 Davies Street, London, W.1.

EXPERIMENTAL OFFICER (with at least higher school certificate in science subjects or general certificate of education 'advanced' in two science subjects or equivalent qualifications, or preferably with higher qualifications in metallurgy, physics or chemistry), to do fundamental research and development work on the metallurgy of plutonium—The Establishment Officer, United Kingdom Atomic Energy Authority, Atomic Energy Research Establishment, Harwell, Didcot, Berks, quoting 2/103/260.

FISHERIES OFFICER (with a university degree in a natural science and an interest in natural history) in the Gold Coast Local Civil Service, to assist in the development of marine and freshwater fisheries, and to investigate scientific and technical problems relating to the fishing industry—The Director of Recruitment, Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting BCD.65/13/01.

GRADUATE PHYSICIST or FUEL TECHNOLOGIST (with ability to apply mathematics to problems of open hearth furnace operation), in the laboratories of the Steelmaking Division, British Iron and Steel Research Association, Sheffield—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting "Steelmaking".

HEAD OF THE DEPARTMENT OF CHEMISTRY (including colour chemistry and dyeing)—The Principal, Technical College, Queen Street South, Huddersfield.

LECTURERS (with a degree or H.N.C. in electrical engineering or physics, and preferably with teaching experience, and a knowledge of R.F. fundamentals and transmission pulse technique, optics, audio frequency engineering or acoustics), in the B.B.C. Engineering Training Department, Evesham, to train staff varying from operator to graduate—Engineering Establishment Officer, Broadcasting House, London, W.1, quoting EX.28N.

PRINCIPAL SCIENTIFIC OFFICER or SENIOR SCIENTIFIC OFFICER (with a first- or second-class honours degree in chemical engineering, and experience of research in that field, or in chemistry, and post-graduate experience either as a physical chemist in the chemical engineering field or as a research chemical engineer), to lead a team concerned with developing special equipment from fundamental studies of a physico-chemical nature, including hydrodynamical and fluid pumping problems, electrochemistry of solutions, chemical kinetics and phase equilibria—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting 561/WGE/34.

PRINCIPAL SCIENTIFIC OFFICER or SENIOR SCIENTIFIC OFFICER (with a first- or second-class honours degree in chemistry or chemical engineering, and many years experience, preferably of work in the fields of casting, pelleting of powders, sintering or slurry pouring), to lead a section consisting of Chemists and Chemical Engineers carrying out development work in a new field of inorganic materials technology, the aim of which is to find the best means of making components from reactive chemicals (Ref. 572/WGE/34); and a SENIOR SCIENTIFIC OFFICER (with a first- or second-class honours degree in chemical engineering or Corporate Member of the Institution of Chemical Engineers, or equivalent qualifications, and several years research or development experience in chemical engineering) to be responsible for the initial design of a special prototype plant for manufacture of an organic chemical, and development into works scale production units (Ref. 573/WGE/34)—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting appropriate Ref. No.

PROFESSOR and an ASSISTANT PROFESSOR or SENIOR LECTURER specializing in taxonomy or ecology—The Dean, College of Arts and Sciences, Baghdad, Iraq.

SCIENTIFIC ASSISTANT (with a knowledge of at least two European languages and training or experience in agricultural (especially soil) science), for work involving abstracting and indexing—The Director, Rothamsted Experimental Station, Harpenden, Herts.

SCIENTIFIC OFFICERS (with a first- or second-class honours degree in chemistry or chemical engineering) for (*a*) to study compatibility of liquid metals with reactive chemical compounds at high temperatures, and materials of construction for chemical plant, and to study protective coatings for such reactive compounds; (*b*) to study rheological properties of slurries, high temperature metals, etc., and the relationship between the properties and chemical and physical constitution; and (*c*) to carry out work concerned with the manufacture of large components from reactive chemicals by such techniques as pressing, casting, pouring, etc.—Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting 574/WGE/34.

SENIOR EXPERIMENTAL OFFICER (preferably with a pass degree in chemical engineering or at least H.S.C. in science subjects) to lead and organize important experimental work on laboratory and pilot scale equipment in the chemical engineering laboratory and ultimately to take charge of a prototype process unit (Ref. 558/WGE/34); and a SENIOR EXPERIMENTAL OFFICER (preferably with a pass degree in physics, or at least H.S.C. in science subjects) to be responsible for the organization and supervision of a small research and development group handling large quantities of highly radioactive materials (Ref. 562/WGE/34)—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting appropriate Ref. No.

SENIOR LECTURER IN MECHANICAL ENGINEERING at the Technical College, Bradford—The Director of Education, Town Hall, Bradford.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

The Engineer Buyers Guide, 1955. Pp. 745. (London: *The Engineer*, 1955.) 5*s*. [211

Association of British Pharmaceutical Industry: a Record of its History and Progress, 1930–1955. Issued on the occasion of the 25th Anniversary of the Association, January 1955. Pp. 32. (London: The Association of British Pharmaceutical Industry, 1955.) [211

Abstracts of papers which have appeared in the *Journal of the British Institution of Radio Engineers* over the past 15 years. Pp. 48. (London: British Institution of Radio Engineers, 1955.) 2*s*. [211

General Register Office. The Registrar General's Quarterly Return for England and Wales. Births, Deaths and Marriages; Infectious Diseases; Weather; Population Estimates. Quarter ended 30th September, 1954. (No. 423.) Pp. 27. (London: H.M. Stationery Office, 1955.) 2*s*. net. [211

Bulletin of the British Museum (Natural History). Geology. Vol. 2, No. 6: Further Contributions to the Solution of the Piltdown Problem. By J. S. Weiner, W. E. Le Gros Clark, K. P. Oakley, G. F. Claringbull, M. H. Hey, F. H. Edmunds, S. H. U. Bowie, C. F. Davidson, C. F. M. Fryd, A. D. Baynes-Cope, A. E. A. Werner and R. J. Plesters. Pp. 225–287+plates 27–31. (London: British Museum (Natural History), 1955.) 20*s*. [211

Imperial College of Science and Technology. Forty-Seventh Annual Report of the Governing Body, 1953–1954. Pp. 65. (London: Imperial College of Science and Technology, 1955.) [211

Aluminium Alloy Sections for Marine Use. (Addendum to Information Bulletin No. 18.) Pp. 12. (London: Aluminium Development Association, 1954.) [211

Sonic and Ultrasonic Methods for Testing Engineering Materials (with particular reference to Concrete). Pp. 12. (Southall, Mddx.: A. E. Cawkell, 1955.) [211

Oxford's Contribution to the Origins of Modern Science. By A. C. Crombie. (A paper read to the British Association for the Advancement of Science at Oxford on 6 September 1954.) Pp. 27. (Oxford: Basil Blackwell, 1954.) 2*s*. 6*d*. net. [211

Journal of the Institution of Electrical Engineers. Vol. 1, No. 1 (January 1955). New Series. Pp. xx+64. Published monthly. (London: Institution of Electrical Engineers, 1955.) 5*s*. [211

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Journal of the West African Science Association. Vol. 1, No. 1 (October, 1954). Pp. 72+1 plate. (London: Charles Knight and Co., Ltd., 1954. Published for the West African Science Association.) [211

Professional Training in the G.E.C. Pp. 28. (London: General Electric Co., Ltd., 1955.) [271

Annual Report of the National Oceanographic Council, 1 April 1953–31 March 1954. Pp. v+28. (Cambridge: At the University Press, 1955.) 5*s*. net. [271

Year Book of the Textile Institute. No. 7: 1954–55. Pp. xviii+248. (Manchester: Textile Institute, 1955.) 15*s*. [271

John Innes Leaflet No. 13: The John Innes High Rate Soil Sterilizer. Pp. 10. (Edinburgh and London: Oliver and Boyd, Ltd., 1955.) 1*s*. net. [271

Irish Republic. Department of Agriculture: Fisheries Branch. Report on the Sea and Inland Fisheries for the year 1953, incorporating Statistics of the Capture of Salmon, Sea Trout and Eels. Pp. 50. (Pr. 2489.) (Dublin: Stationery Office.) 2*s*. 6*d*. [271

Proceedings of the University of Durham Philosophical Society. Vol. 12, No. 1: A Preliminary Account of the Geological Structure of North Northumberland and the Borders. By Dr. D. A. Robson. Pp. 9. Vol. 12, No. 2: The West Sleekburn Tholeiite which Contains a Large Cavity. By B. A. O. Randall. Pp. 10–13. Vol. 12, No. 3: The Shape and Nature of the Pre-Glacial Wear Valley between Cocken and Chester-le-Street, County Durham. By D. H. Maling. Pp. 14–28. (Durham: University of Durham Philosophical Society, 1954.) [271

Other Countries

Annals of the New York Academy of Sciences. Vol. 60, Art. 1: Speciation and Variation in Asexual Fungi. By Kenneth B. Raper and 22 other Authors. Pp. 182. Vol. 60, Art. 2: 6-Mercaptopurine. By George H. Hitchings and 84 other Authors. Pp. 183–508. 4.50 dollars. (New York: New York Academy of Sciences, 1954.) [211

The Commonwealth Fund. Thirty-sixth Annual Report for the year ending June 30, 1954. Pp. ix+42. (New York: Commonwealth Fund, 1954.) [211

Publicazioni della Universita Degli Studi di Firenza—Facolta di Scienze Matematiche, Fisiche e Naturali. Fascicolo Nr. 69: Osservazioni e Memorie dell' Osservatorio Astrofisico di Arcetri. Pp. xv+164. (Firenze: Universita di Firenze, 1954.) [211

Berichte des Deutschen Wetterdienstes. Nr. 14: Charakteristikenverfahren in der numerischen Wettervorhersage. Von Karl Hinkelmann und Rudolf Schwarzenberger. Pp. 26. (Bad Kissingen: Deutschen Wetterdienstes, 1954.) [211

Publications de l'Institut National pour l'Étude Agronomique du Congo Belge. Carte des Sols et de la Végétation du Congo Belge et du Ruanda-Urundi. 4:—Nioka (Ituri). A, B et C. Notice Explicative de la Carte des Sols et de la Végétation. Par N. Holowaychuk, I. Denisoff, P. Gilson, J. Groegaert, L. Liben et T. Sperry. Pp. 31. D: Geomorphologie. Geology of the Soils of the Nioka-Ituri Area, Belgian Congo. By Robert V. Ruhe. Pp. 27. (Bruxelles: l'Institut National pour l'Étude Agronomique du Congo Belge, 1954.) [211

University of Illinois. Engineering Experiment Station Bulletin No. 424: The Distribution of Concentrated Loads by Laminated Timber Slabs. By Prof. Whitney C. Huntington, Prof. William A. Oliver, Melvin W. Jackson and William T. Cox. Pp. 69. 1 dollar. No. 425: Effect of Body Feed on the Filtration of Water through Diatomite. By Prof. Harold E. Babbitt and E. Robert Baumann. Pp. 40. 0.80 dollar. No. 426: Inelastic Behavior of Ductile Members Under Dead Loading. By Prof. M. E. Clark, Prof. H. T. Corten and Prof. O. M. Sidebottom. Pp. 48. 1 dollar. No. 427: Outdoor-Air Supply and Ventilation of Furnace Closet Used with a Warm-Air Heating System. By Prof. Robert W. Roose, Norman A. Buckley and Prof. Seichi Konzo. Pp. 50. 1.70 dollars. (Urbana, Ill.: University of Illinois, 1954.) [211

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Deutsche Akademie der Wissenschaften zu Berlin. Institut für Physikalische Hydrographie. Acta Hydrophysica. Herausgegeben von H. Ertel und J. Fischer. Band 2, Heft 1: Über eine "nicht nomographierbare" Funktion. Von Joh. Fischer. Beiträge zum Problem brandender Wellen. Von Kurt Vollbrecht. Pp. 30. Band 2, Heft 2: Über die Reflexion der diffusen Himmelstrahlung an einer unbewegten Wasseroberfläche. Von H. Grieseier. Zur Frage der Sedimentbewegung im litoralen Gürtel. Von K. Vollbrecht. Pp. 31–80. (Berlin: Akademie-Verlag, 1954.) [271

Falkland Islands and Dependencies. Meteorological Service. The Meteorology of the Falkland Islands and Dependencies, 1944–1950. By Dr. J. Pepper. Pp. vi+249 (15 plates). Stanley, Falkland Islands: Meteorological Service; London: Crown Agents for Overseas Governments and Administrations, 1954.) 42*s*. [271

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University of Adelaide—School of Geology. Publication No. 238: Stratigraphy and Structure of the Northern Territory of Australia. By Paul S. Hossfeld. Pp. 58+3 plates. (Adelaide: The University, 1954.) [281

Rendiconti Istituto Superiore di Sanità. Volume 17. English edition. Pp. x+243+46 plates. (Roma: Fondazione Emanuele Paterno; Oxford: Blackwell Scientific Publications, Ltd., 1954.) 5000 lire; 57*s*. 6*d*. [1

Bulletin of the Museum of Comparative Zoology at Harvard College. Vol. 112, No. 5: The Comparative Biology of Reproduction in the Wood-boring Isopod Crustacean *Limnoria*. By Robert J. Menzies. Pp. ii+363–388. (Cambridge, Mass.: Museum of Comparative Zoology at Harvard College, 1954.) [1

Museum of Comparative Zoology at Harvard College. Breviora. No. 38 (November 28, 1954): *Omnia* (Trilobita) from Venezuela. By H. B. Whittington. Pp. 7 (1 plate). No. 39 (November 24, 1954): New or Redescribed Pelomedusis Skulls from the Tertiary of Africa and Asia (Testudines, Pelomedusidae). 2: A Podocnemide Skull from the Miocene of Moghara, Egypt. By Ernest Williams. Pp. 8+4 plates. No. 40 (November 29, 1954): Some Mollusks from the Continental Slope of Northeastern North America. By Arthur H. Clarke, Jr. Pp. 11. No. 41 (December 17, 1954): Comments on the Classification of Rodents. By Albert E. Wood. Pp. 9. (Cambridge, Mass.: Museum of Comparative Zoology at Harvard College, 1954.) [1

U.S. Department of Commerce: Weather Bureau. Technical Paper No. 23: Floods of 1952—Upper Mississippi—Missouri—Red River of the North. Prepared by the Hydrologic Services Division. Pp. vi+93 (12 plates). (Washington, D.C.: Government Printing Office, 1954.) 1 dollar. [1